SFUND RECORDS CTR
1652-00088

RECORD OF DECISION
IRON MOUNTAIN MINE
REDDING, CALIFORNIA

SFUND RECORDS CTR
54087

DOCUMENTS REVIEWED:

I am basing my decision primarily on the following documents describing the cost-effectiveness of remedial alternatives for the Iron Mountain Mine site:

- Final Remedial Investigation Report, Iron Mountain Mine, near Redding, California, CH2M Hill, August 1985.
- Public Comment Feasibility Study, Iron Mountain Mine, Redding, California, CH2M Hill, August 2, 1985.
- Public Comment Feasibility Study Addendum, Iron Mountain Mine, Redding, California, dated July 25, 1986.
- Responsiveness Summary, dated September 1986.
- Summary of Remedial Alternative Selection, September 19, 1986.

DESCRIPTION OF OPERABLE UNIT:

- Cap selected cracked and caved ground areas on Iron Mountain above the Richmond ore body using a soil-cement mixture or other suitable material *;
- Divert clean surface water in Upper Spring Creek to Flat Creek, divert clean surface water in South Fork Spring Creek to Rock Creek, and divert clean Upper Slickrock Creek water around waste rock and tailings piles;
- Enlarge Spring Creek Debris Dam (SCDD) from its present capacity of 5,800 acre feet to 9,000 acre feet;
- Implement perimeter control as needed to minimize direct contact threat; and
- Perform hydrogeologic study and field-scale pilot demonstration to better define the feasibility of utilizing low-density cellular concrete to eliminate or reduce acid mine drainage formation.

* [Based on the present record, I believe that construction of a partial cap over the Richmond ore body is a necessary source control component of the overall remedy as envisioned by EPA. However, the potentially responsible parties are proposing to

implement a solution mining operation that may be able to effectively exploit the ore body as a resource and control the discharge of acid mine drainage from the mountain. Construction of the partial cap could adversely affect the solution mining operation. EPA intends to further explore the implementation and environmental results associated with a solution mining operation during the next 60 days. Therefore, no action will be taken to implement the capping component for a period of at least 60 days from the signature date on this Record of Decision. To the extent that new information causes EPA to modify its present opinion that the mountain should be partially capped, EPA would provide to the public an opportunity to comment prior to making any final decision. I will make a decision regarding the implementation of the capping component after the 60-day period has ended.]

DECLARATIONS:

Consistent with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) 40 CFR Part 300 et.seq., I have determined that the operable unit remedy previously identified is a component of what will be the appropriate Fund-financed action for this site in accordance with section 300.68 (j) of the NCP. These are components of a final EPA remedy that will provide adequate protection of the public health and welfare and the environment.

* The selected operable unit, and ultimately the final remedy, will not meet all the requirements of the Clean Water Act (CWA) 33 U.S.C. §1251 et.seq. and, therefore, is somewhat less protective than the remedial action alternative that complies with all federal and state regulations. The reason is that federal water quality standards will be met in the Sacramento River below Keswick Dam but not in the immediate receiving waters as required by the CWA. Also, if treatment is required, not all point source discharges will receive Best Available Technology and not all non-point sources will be addressed through Best Management Practices. However, the final remedy is expected to be substantially effective in minimizing the discharge of heavy metals from the site which would threaten public health and welfare or the environment. I have determined that the level of protection provided by the operable unit most effectively mitigates and minimizes threats to and provides adequate protection of public health and welfare and the environment considering the need for additional protection at this site and the amount of money that may be available in the Hazardous Substance Trust Fund to respond to other sites which present or may present a threat to public health and welfare and the environment. I have also determined

that the selected remedy is that remedy which most closely approaches the level of protection provided by applicable or relevant and appropriate Federal requirements considering the specific fund-balanced sum of money available for the Iron Mountain Mine site.

The State of California has been consulted and agrees with the approved operable unit and EPA's strategy leading to the implementation of a final remedy. All aspects of the Iron Mountain Mine remedy will be implemented in a phased approach, with the enlargement of Spring Creek Debris Dam (SCDD) being the last component remedy constructed. The reason for this is that the actual effectiveness of the other component source control, treatment, and water management alternatives will not be known until each component has been installed and monitored. Only until these actions are completed will EPA know the exact enlargement of SCDD needed to ensure that project cleanup objectives will be met. Therefore, this ROD will authorize enlargement of SCDD, but EPA will not begin the remedial action phase until the effectiveness of other component remedies has been determined. The operable unit will require future operation and maintenance activities to ensure the continued effectiveness of the alternatives. These activities will be considered part of the approved action and eligible for Trust Fund monies for a period not to exceed one year.

I have determined that a hydrogeologic investigation and a field-scale pilot demonstration test to determine the technical feasibility of injecting low-density cellular concrete into the underground mine workings, are appropriate next steps in determining the scope of the final remedy for Iron Mountain Mine. EPA believes that low-density cellular concrete may constitute a permanent approach to the reduction of acid mine drainage formation.

10/3/86
Date

J Winston Porter

J. Winston Porter
Assistant Administrator,
Office of Solid Waste and
Emergency Response

SUMMARY OF REMEDIAL ALTERNATIVE SELECTION

Iron Mountain Mine
Redding, California

September 19, 1986
Prepared by Thomas A. Mix
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Toxics and Waste Management Division
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SITE: Iron Mountain Mine
REGION: IX

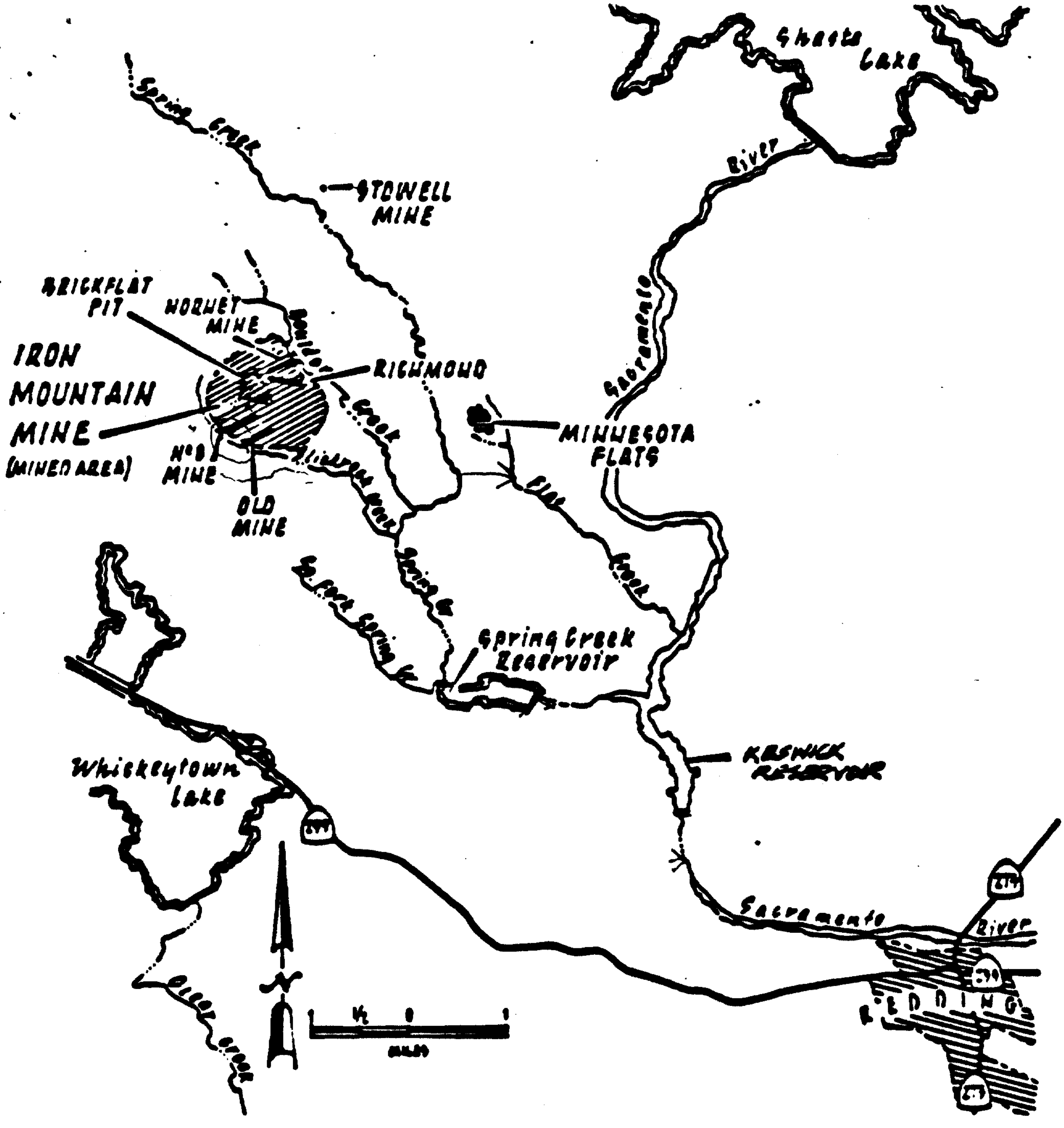
I. SITE LOCATION AND DESCRIPTION

Iron Mountain Mine is located in the southeastern foothills of the Klamath Mountains, approximately nine miles northwest of the City of Redding, California (See Figure 1). Between the 1860's and 1962, Iron Mountain Mine was periodically mined for iron, silver, gold, copper, zinc, and pyrite. The mine area is located on 4,400 acres of property that includes underground workings, an open pit mining area, waste rock dumps, and tailings piles. The rugged topography of the area is typical of a mountainous region with steep slopes bissected by streams. Elevations range from 600 feet on the Sacramento River several miles east of the mine, to 3,800 feet on top of Iron Mountain. The climate of the Iron Mountain area is characterized by warm, dry summers and cool, rainy winters.

Iron Mountain averages 70- 80 inches of precipitation per year, most of it falling in the form of rain between the months of November and April. Snow accumulation of several inches is common above the 2,000 foot elevation during the November- March storms, but usually melts in a few days.

Iron Mountain is drained by Boulder Creek to the north, and Slickrock Creek to the south of the mine. Boulder Creek, a perennial stream, receives a portion of its flows from the Lawson and Richmond adits via their mine portals. Slickrock Creek, an intermittent stream, receives discharges from underground seepage associated with Old Mine and/or No. 8 Mine and flows from storm water drainage from the Brick Flat Pit area. A debris slide diverted the original Slickrock Creek drainage and buried adits from which acid mine drainage is emanating. Two copper cementation plants are located on site and function to remove copper from controlled flows, such as those collected from mine portals and conveyed to the plants by a system of flumes. Uncontrolled flows such as surface runoff containing acid and heavy metals are discharged directly to receiving waters without treatment.

Slickrock and Boulder Creeks flow southeastward into Spring Creek. The Spring Creek Debris Dam and Reservoir were built in 1963 as part of the Central Valley Project (CVP). Since 1963, the waste has been collected in Spring Creek Reservoir and subsequently metered into Keswick Reservoir. The flow releases of the waste from the Spring Creek Reservoir is determined by the



Shasta Lake
River
Sacramento
Spring Creek
STOWELL MINE
BRICKFLAT PIT
HORNET MINE
IRON MOUNTAIN MINE (MINED AREA)
RICHMOND
No 8 MINE
OLD MINE
MINNESOTA FLATS
Spring Creek Reservoir
KESWICK RESERVOIR
Whiskeytown Lake
Sacramento River
REDDING
MILES

FIGURE 1

amount of "dilution" water being released by the U.S. Bureau of Reclamation from Shasta Lake. A principle objective in operating the reservoir is to control the discharge of the contaminated water such that releases upstream from Shasta Lake provide sufficient dilution to meet current established levels for copper, zinc, and cadmium in the Sacramento River. Spring Creek drains into Keswick Reservoir which was formed by the construction of the Keswick Dam on the Sacramento River. Flat Creek, which also drains a portion of the mining complex, enters Keswick Reservoir just upstream of Spring Creek. The Sacramento River is a valuable fisheries resource and is used as a source of drinking water by the City of Redding (population: approximately 50,000 people).

II. OVERVIEW OF THE PROBLEM

Mineralized zones that have extensive underground workings from past mining activities are the primary source of contamination. As rain falls on the ground above the mineralized zones, it infiltrates into the underground mine workings where it mixes with groundwater, and then passes through the ore zone. As the groundwater passes through the ore, sulfuric acid is produced, and high concentrations of copper, zinc, and cadmium are leached from the mineralized zone. The resulting heavy metals- laden acidic waters are referred to as acid mine drainage (AMD).

The AMD is eventually discharged through mine adits (access tunnels entering the orebody and used during underground mining activities) or groundwater seepage into streams in the Spring Creek watershed (Slickrock Creek and Boulder Creek). The AMD mixes with runoff from the Spring Creek watershed and flows into Spring Creek Reservoir. This reservoir serves to control discharges from the Spring Creek watershed into the Sacramento River.

During periods of heavy winter rain, high volumes of runoff are produced from the Spring Creek watershed. This also coincides with high production of AMD from Iron Mountain Mine. At these times, releases from Shasta Lake are frequently reduced to maximize storage behind Shasta Dam and to prevent downstream flooding of the Sacramento River. When high runoff causes the Spring Creek Reservoir to exceed capacity, uncontrolled spills have occurred. Under these conditions, the releases from Shasta Lake are at times not sufficient to provide adequate dilution of the uncontrolled discharge from the reservoir. As a result, levels of copper, zinc, and cadmium exceeding lethal concentrations for aquatic life periodically occur in the Sacramento River. The last major adult fish kill occurred in 1969 when an estimated 200,000 salmon were killed. More often, sublethal concentrations occur that have detrimental effects on some aquatic species, including reduced rates of growth, interference with physiological processes necessary for successful migration, and inhibition of gill function. Past investigations in the Iron Mountain Mine area have documented the following environmental conditions which now exist and will continue as a result of toxic drainage from Iron Mountain Mine:

1. Heavy metal contamination of Boulder Creek, Slickrock Creek, Flat Creek, and portions of Spring Creek, causing the elimination of aquatic life and all other beneficial uses of these watercourses downstream of Iron Mountain Mine.

2. Heavy metal contamination of Keswick Reservoir, causing periodic fish kills ad a significant reduction in fish and aquatic invertebrates and unsightly deposits of metallic sludges in the lower one and one-half miles of the Reservoir downstream of Spring Creek. This contamination has reduced, if not eliminated, recreational uses of the lower Reservoir.

3. Periodic fish kills in Keswick Reservoir and in the Sacramento River downstream of Keswick Dam caused by uncontrolled spills of contaminated water from Spring Creek Reservoir. In addition, there are repeated instances when the LC50 levels for juvenile salmon and steelhead in the Sacramento River below Keswick Dam are exceeded. These instances are caused by uncontrolled spills at Spring Creek Reservoir. In addition, short-term exposure (6-8 hours) to high concentrations of heavy metals occurs below Keswick Dam from normal water releases at Spring Creek Reservoir during the Spring Creek powerhouse start-up.

4. Accumulation of copper and cadmium in the tissue of resident fish below Keswick Dam at levels which greatly exceed the statewide norm and which suggest adverse reproductive and other physiological impacts. In the case of cadmium, the levels in fish tissue below Keswick Dam are over five times the statewide norm.

5. Temporary discontinuation of domestic water from the Sacramento River for precautionary reasons during uncontrolled spill events at Spring Creek Reservoir.

6. Occasional loss of large volumes of fresh water in storage when the U.S. Bureau of Reclamation has had to release water from Shasta Dam to dilute high concentrations of heavy metals spilling from Spring Creek Reservoir.

III. SITE HISTORY

A. Mining History

Iron Mountain Mine is the southernmost mine in the West Shasta Mining District, an area mined since the early 1860's for silver, gold, copper, zinc, and pyrite. Although various parts of Iron Mountain Mine were developed as separate mines, it is generally believed that the massive sulfide deposits are part of one orebody which has been segmented by faulting.

Iron Mountain Mine was first secured for possible future value as a source of iron ore in 1865. Silver ore was discovered in 1879, and limited development and mining or Iron Mountain Mine's gossan (oxide ores) caps began. A small milling and leaching facility was constructed in the mid-1980's to process the gossan material for silver recovery. In 1895, the Iron Mountain Mine property was sold to British-owned Mountain Mining Company, Ltd., following discovery of massive copper sulfide deposits. Mining of the ore continued under the new ownership until 1897, when the property was transferred to Mountain Copper Company, Ltd., of London, England.

The Old Mine orebody was the first massive sulfide ore to be mined for commercial recovery of copper at IMM. Construction of a smelter and a narrow-gauge railway to transport the ore from the mine to the smelter was completed in 1896.

Between 1902 and 1908, several lawsuits were brought against Mountain Copper Company. Private property owners and the U.S. Forest Reserve sued Mountain Copper for destruction of vegetation by operation of the Keswick smelter, and an injunction was obtained prohibiting the roasting of ore. Smelting was gradually transferred to Richmond, California, and in 1907 the Keswick smelter was completely shut down. Mountain Copper completed a new smelter and processing plant in Martinez, California in 1908.

The Number 8 orebody, underlying the Old Mine orebody, was discovered in 1907. The Number 8 Mine was developed concurrently with the Hornet pyrite mine on the northeast side of the mountain. Beginning in 1900, pyrite ore from the Old Mine, and later the Hornet Mine, was sold for the production of sulfuric acid. Process residues were returned to Mountain Copper Company's Keswick Smelter for recovery of the copper, gold, and silver. The procedure was greatly simplified with completion of Mountain Copper's Martinez plant in 1908. The Martinez plant was complete with copper smelter, an acid plant, and facilities for manufacturing commercial fertilizers.

In 1914-15, California's first copper flotation mill was completed at Minnesota, on the Iron Mountain railway. The mill operated until March 1919, when it was closed because of low copper prices. A nearly flat area, later referred to as Minnesota Flats, was used for tailings disposal during the operation of the mill. Pyrite ore tailings were also deposited at Minnesota Flats during later periods of mining.

In 1920, a new crushing and screening plant was put into operation near the Hornet Mine to replace the crushing operations at Keswick. It was operated until 1943. An aerial tramway was completed in 1921 to transport the ore to Matheson, a few miles north of ~~K~~eswick on the Southern Pacific Railroad line.

In 1928, as the copper market improved, the Minnesota mill was reconstructed just below the Number 8 Mine portal. However, tailings disposal in the steep canyon was a major problem; a tailings dam built on Slickrock Creek received numerous complaints from the California Fish and Game Commission. The dam was destroyed by floods in 1933, and the operation was shut down due to declining copper prices. A 250-ton/day cyanide leach plant was constructed in 1929 to recover silver and gold from the gossan in the area of the Old Mine orebody. The gossan was 23ned by open-pit methods, with tailings storage in Hogtown Gulch, adjacent to Slickrock Creek. An estimated 2.6 million tons of gossan was mined from 1929 to 1942. The tailings initially stored in Hogtown Gulch, were reported to have an iron content of 50 to 55 percent; during later periods, the content was reported to be as low as 30 to 35 percent.

Mining of the copper-zinc ore in the Richmond and Mattie orebodies was begun in 1942. High wartime metals prices prompted construction of a copper-zinc flotation plant at the Richmond portal. The plant operated from 1943 to 1947. Underground mining of the Richmond orebody ended in 1956.

In 1955, a large landslide composed of mine mill tailings filled the Slickrock Creek canyon to a reported depth of about 80 feet, covering two mine portals (Number 8 and Old Mine).

The Brick Flat orebody was mined by open-pit methods between 1955 and 1962. The first pyrite was mined in 1956 after the removal of 2.5 million tons of overburden. All mining operations were discontinued in 1963.

The Iron Mountain property was purchased from Mountain Copper Company by Stauffer Chemical Company in 1967. The property was subsequently sold to Iron Mountain Mines, Inc., in 1976. There has been some core sampling, but there is no evidence that mining has occurred under the current ownership.

B. Previous Remedial Actions

Several actions have been taken that have had an effect on the incidence and severity of AMD problems at Iron Mountain Mine. These measures, although lessening the pollution problems somewhat, have not been successful in eliminating the conditions discussed on page 4 of this document.

1. Copper Cementation Plants

In 1940, Mountain Copper Company, Ltd., constructed a copper cementation plant to recover copper from mine drainage in the Boulder Creek drainage area. In the cementation process, scrap iron is contacted with the AMD resulting in the precipitation of copper and dissolution of the scrap iron.

The Boulder plant and a similar plant in the Slickrock drainage, which was constructed by Iron Mountain Mines, Inc., in 1977, have been operated intermittently to recover copper from the AMD, thereby reducing concentrations of copper in Spring Creek and the Sacramento River. The copper cementation plants remove approximately 300 pounds per day (annual average) of copper from the AMD when properly operated. Zinc and cadmium, and other elements are not removed by this treatment method.

2. Spring Creek Debris Dam

The SCDD was constructed in part to help prevent toxic concentrations of metals and consequent fishkills as a result of discharges of AMD to Keswick Reservoir. The objective is to release AMD from SCDD at a rate which will result in safe metal concentrations below Keswick Dam. The debris dam has not been entirely effective in achieving this objective, particularly during periods of high precipitation which can produce runoff that exceeds storage capacity of SCDD. This results in uncontrolled spills of AMD. When Sacramento River base-flow is being stored at the same time to conserve water in Shasta Lake or to minimize downstream flooding, these acid metal-laden flows from SCDD are not diluted sufficiently to prevent fishkills, especially in the early life stages of fish.

In 1980, a Memorandum of Understanding (MOU) was developed between the State Water Resources Control Board (SWRCB), U.S. Bureau of Reclamation (USBR), and the California Department of Fish and Game (CDFG) for the purpose of minimizing the Spring Creek toxicity problem.

As part of this MOU, the USBR agreed to operate the Spring Creek Debris Dam and Shasta Dam water management system in such a manner that, to the extent possible, sufficient dilution water would be available to ensure that State water quality criteria below Keswick Dam would be met.

Also, under the agreement, the CDFG was to conduct fish toxicity tests to provide a basis for permanent toxicity criteria, release schedules, and water quality objective. After two years of intensive laboratory and field work, the CDFG identified the following levels of metals below which protect all life stages of anadromous salmon and steelhead below Keswick Dam: copper (5.6 ug/l); zinc (16.0 ug/l); and cadmium (0.22 ug/l). These recommended levels were adopted by the Regional Water Quality Control Board as Basin Plan objectives for the Keswick Dam area and approved by the State Water Resources Control Board (SWRCB) in August 1984. These objectives were approved by EPA on August 7, 1985 under Section 303 of the Clean Water Act.

The Regional Board, acting on behalf of the SWRCB, was responsible for undertaking environmental studies designed to identify the most feasible means of mitigating the problem through source control. The MOU may be revised once remedial action is completed at Iron Mountain Mine.

IV. EPA INVOLVEMENT

In June 1981, the State of California submitted the Iron Mountain Mine site as a candidate for the Interim Priorities List (IPL). When the IPL was released in October 1981, Iron Mountain Mine appeared in the fourth decade of candidate sites. Later, on August 31, 1982, the state submitted Iron Mountain Mine as a candidate for the National Priorities List (NPL). On December 30, 1982, EPA proposed the Iron Mountain Mine site for inclusion on the NPL. On September 8, 1983, through final rule-making, the site was included on the NPL.

In September 1983, EPA commenced a Remedial Investigation and Feasibility Study (RI/FS). The purpose of the RI was to assess the major sources of contamination leaving the site and collect data needed to identify and evaluate potential remedies. During the FS, the potential remedies were evaluated according to technical, environmental, public health, institutional, and cost criteria.

A. Remedial Investigation (RI)

A comprehensive investigation for the Iron Mountain Mine site was conducted between September 1983 and April 1985 to determine the nature, cause and extent of the environmental and potential public health impacts from past and continuing discharges of AMD. The extent of the surface and ground water contamination was established through:

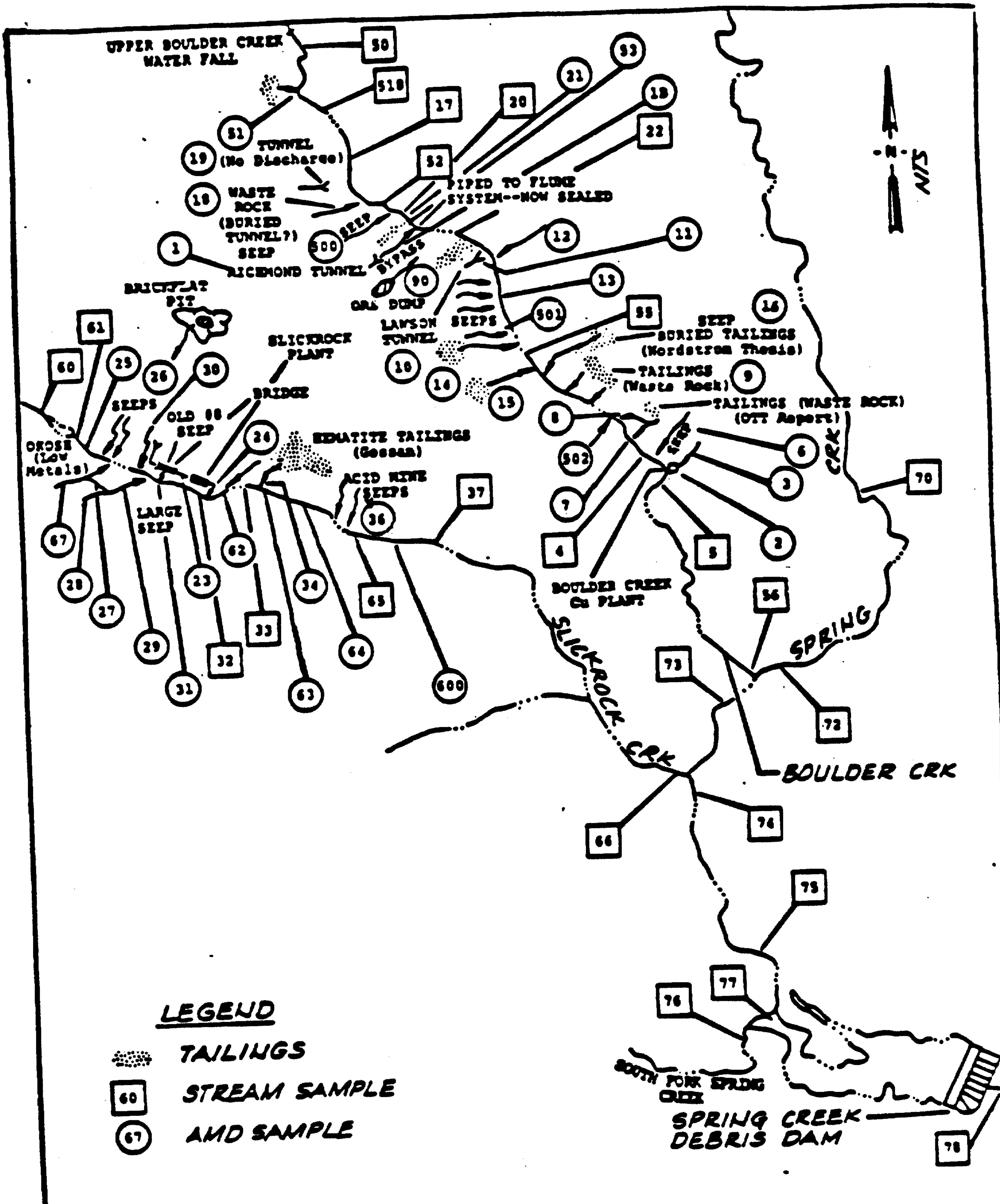
- Weekly sampling of the five major sources at the mine and three locations on Spring Creek, and bi-weekly sampling at 4 locations along the Sacramento River for heavy metals.

- Installation of flow measurement stations at 8 locations, including mine portals and downstream receiving waters.

- Measurement of precipitation at six gauges throughout the area.

- Two comprehensive surface water sampling surveys, involving 76 sampling points were conducted in September 1983 and December 1983 to identify and quantify all AMD sources. (See Figure 2)

- A review of existing information on the site including water quality, geology, and hydrology.



INTENSIVE SAMPLING SITE LOCATION MAP

* A program of field mapping of the areas overlying the Richmond orebody. This included geologic mapping, measurement of fracture orientations, and delineation of subsidence pits and their tributary drainage areas.

* A program of drilling and monitoring for the Richmond groundwater investigation. This program included installing four monitoring wells adjacent to the Richmond orebody, monitoring groundwater elevations, conducting aquifer testing, and groundwater quality testing.

During the 17 month RI, approximately 450 surface and ground water samples were collected and analyzed. A draft RI report was released in December 1984; the RI report was finalized and issued on August 23, 1985. The major findings of the RI are discussed below.

1. Major Sources of Pollution

EPA's RI found that the following five major sources account for approximately 72 percent of the copper and 86 percent of both zinc and cadmium being discharged from the site during the sampling period.

Richmond Portal: This source is a mine adit into the Richmond orebody which represents the major single source of AMD at Iron Mountain Mine. The Richmond orebody has been extensively mined, resulting in subsidence pits and closed drainages on the surface overlying the zone. Water which drains from the Richmond portal results from infiltration of surface water captured in the closed drainage areas overlying the orebody and by lateral inflow of groundwater from areas upgradient of the mine.

Lawson Portal: This source is a mine shaft located on Boulder Creek immediately below and to the east of the Richmond portal.

Old No. 8 Mine Seep: This source is located on the upper end of Slickrock Creek and is believed to originate from either the No.8 Mine and/or the Old Mine. The entryways for these mines were covered by a slide in the 1950's.

Big Seep (below Okosh Mine): This source is made up of seeps which discharge from the waste rock dump on the south side of Slickrock Creek.

Brick Flat Pit By-Pass: Water that is discharged from this source originates from the drainage area into Brick Flat Pit and is carried outside the pit by an earthen dam.

The relative contribution of metals from these sources is listed in Table 1; the average chemical composition of discharges from these sources is shown on Table 2.

Table 1. Relative Contribution of Metals Averaged over 4 month Sampling Program

SOURCE	COPPER Average lbs/day	COPPER % of All Sources	ZINC Average lbs/day	ZINC % of All Sources	CADMIUM Average lbs/day	CADMIUM % of All Sources	MAXIMUM DISCHARGES Cu,Zn & Cd Lbs/Day
Richmond Portal	180	31.0	1,118	70.0	7.8	69.0	5,600
Lawson Portal	32	6.0	209	11.0	1.4	11.0	1,100
Old No. 8 Mine Seep	109	25.0	45	3.0	0.4	4.0	1,000
Big Seep	50	9.0	21	1.0	0.2	1.0	400
Brick Flat Pit By-Pass	52	2.0	73	1.0	0.6	1.0	1,000
Other Sources		27.0		14.0		14.0	
TOTAL	423	100.0	1,466	100.0	10.4	100.0	

Table 2

SUMMARY OF MAJOR SOURCES--

AVERAGE CHEMICAL COMPOSITION

(DECEMBER 30, 1983 - MAY 16, 1984)

Parameter (mg/L, except as noted)	Richmond Portal	Lawson Portal	Old-No. 8 Mine Seep	Big Seep	Brick Flat Pit Bypass
Flow (gpm)[a]	73	50	89	277	35
pH (units)	0.6 to 1.4	1.6 to 2.8	1.7 to 3.1	2.2 to 3.1	2.3 to 4.6
Conductivity (Umhos/cm)	195,000	30,900	7,600	1,350	2,610
Temperature (°C)	26.5	20.4	16.2	9.9	11.7
Acidity (meq/L)	1,150	232	131	16	37
Aluminum	1,190	484	509	47	49
Antimony	0.295	<0.02	<0.02	<0.02	<0.02
Arsenic	34.5	4.6	0.19	0.03	0.47
Cadmium	10.1	2.4	0.46	0.05	0.41
Calcium	163	178	90	5	44
Chloride	75	5	10	4	2
Copper	184	55	120	12.9	14.4
Iron, total	13,000	3,560	1,270	141	369
Iron, ferrous	11,400	2,930	940	57	259
Lead	3.15	0.21	0.014	0.026	0.70
Magnesium	586	329	293	16	68
Manganese	13.5	9.0	11.9	0.44	1.8
Mercury (Ug/L	1.4	<0.1	0.1	<0.1	<0.2
Potassium	153	38	0.8	<0.3	0.5
Silica	23.8	15.0	18.9	2.6	8.1
Silver	0.014	<0.001	<0.001	<0.008	<0.001
Sodium	112	31	6.1	3.3	3.0
Sulfate	60,100	13,400	6,800	690	1,530
Thallium	0.19	0.03	<0.01	<0.01	<0.01
Total dissolved solids	69,400	19,000	10,900	1,100	2,500
Total suspended solids	92	20	11	9	6
Zinc	1,440	350	48.9	4.8	56.5

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[a] [illegible] of the flow measurements obtained at the time of sampling.

a) Boulder Creek

The existing water quality in Boulder Creek is quite variable and highly dependant on rainfall and the operation of the existing Boulder cementation plant. Boulder Creek water quality data is presented in Table 3. The sources of contamination along Boulder Creek consist of the following:

- Boulder Creek Cementation Plant

The Boulder Creek cementation plant receives acid mine drainage discharge continually from the Richmond and Lawson mine portals through a series of pipes and flumes. Leaks and spills from the collection system are additional minor sources of pollutant discharges. The quantity of the discharge from this plant is dependent on rainfall, and the quality is dependent on whether scrap iron is being maintained in the treatment plant.

It is estimated that the discharge from the Boulder cementation plant contributes approximately 20 to 40 percent of the copper, 90 to 95 percent of the cadmium, and 90 to 95 percent of the zinc measured in Lower Boulder Creek.

- Seeps

Numerous seeps exist along the Boulder Creek drainage. The primary source of these seeps may be acid mine drainage from the main orebody. Flows from these seeps are greatly reduced during the summer months and some may stop completely. The quality of these seeps is as follows:

Parameter	Range
pH	0.4 to 6.1 units
Cadmium, total	0.005 to 0.52 mg/l
Copper, total	1.0 to 13.4 mg/l
Zinc, total	0.3 to 59.7 mg/l

The percent contribution of seeps to Boulder Creek is listed on Table 4.

TABLE 3: Boulder Creek Water Quality

Parameter	Upper Boulder (Summer) Sept 1983	Upper Boulder (Winter) Dec 1983	Lower Boulder (Summer) Sept. 1983	Lower Boulder (Winter) Dec. 1983	Lower Boulder (Spring) May 1984
pH, units	6.8	6.3	2.25	1.8	--
Cadmium, total, mg/l	0.012	0.001	1.64	0.44	0.65
Copper, total, mg/l	<0.050	<0.050	3.52	1.45	1.10
Zinc, total, mg/l	0.912	0.020	302.00	46.2	90.3

o <u>Tailings Piles and Waste Dumps</u>

These sources contribute pollutants primarily during storm events. In addition to dissolved metals and acidic leachate, tailings and waste material are discharged directly to receiving waters in violation of federal suspended solids limitations and water quality standards. The percent contribution of these soures to Boulder Creek is listed on Table 4.

o <u>Other Sources</u>

Other sources of metal pollution probably consist of subsurface drainage entering Boulder Creek and dissolution of metal-bearing sediment in the creek. These other sources of pollution are estimated to be as follows:

	Summer		Winter	
Metal	lb/day	Percent Contribution	lb/day	Percent Contribution
Copper	8.7	76	26	23
Cadmium	0.2	3	0	0
Zinc	31.0	4	30	1

b) <u>Flat Creek</u>

The only identified source of pollutants discharged to Flat Creek is the Minnesota Flats tailings pile. The water quality of Flat Creek below Minnesota Flats is given below.

Parameter	Average	Range
Flow	280 gpm	58 to 9,000 gpm
pH	--	2.6 to 6.5 units
Copper	1.32 mg/l	0.003 to 7.63 mg/l
Cadmium	0.018 mg/l	0.002 to 0.050 mg/l
Zinc	1.92 mg/l	0.48 to 9.02 mg/l

c) <u>Slickrock Creek</u>

The existing water quality in Slickrock Creek is quite variable and highly dependent on rainfall and the operation of the Slickrock cementation plant. Slickrock Creek water quality data is presented in Table 5. The sources of contamination along Slickrock Creek consist of:

TABLE 4

Percent Contribution of Boulder Creek Seeps and Tailings Piles Waste Rock Dumps

	Percent Contribution (Range)	
Metal	Seeps	Tailings Piles and Waste Rock Dumps
Cadmium	0.1 - 3	0.1 - 7
Copper	3.1 - 17	0.7 - 20
Zinc	0.1 - 3	0.1 - 4

TABLE 5: Slickrock Creek Water Quality

Parameter	Upper Slickrock (Summer) Sept 1983	Upper Slickrock (Winter) Dec 1983	Lower Slickrock (Summer) Sept. 1983	Lower Slickrock (Winter) Dec. 1983	Lower Slickrock (Spring) May 1984
pH, units	6.9	6.3	2.9	2.8	--
Cadmium, total, mg/l	0.001	<0.001	0.21	0.056	0.073
Copper, total, mg/l	<0.05	<0.05	27.1	8.50	9.47
Zinc, total, mg/l	--	<0.01	18.5	4.95	10.45

o Slickrock Cementation Plant

The Slickrock cementation plant receives acid mine drainage discharged continually from the Old-No. 8 mine seep. The quantity of the discharge from the cementation plan is dependent on rainfall, and the quality is dependent on whether scrap iron is maintained in the treatment tanks. It is estimated that the discharge from the Slickrock cementation plant contributes approximately 75 to 95 percent of the copper, cadmium, and zinc measured in Lower Slickrock Creek.

o Seeps

A few seeps exist along Slickrock Creek. The primary source of metals in these seeps appears to be from the old slide area, and from the hematite pile. It is also possible that the source of these seeps may be AMD from the main orebody. The major contributing seep is Big Seep. The source of the seep area is groundwater and surface water migrating through an old waste rock dump. The quality of the Slickrock seeps is as follows:

Parameter	(mg/l)
pH	2.7 to 6.5 units
Cadmium, total	0.001 to 0.30 mg/l
Copper, total	<0.050 to 42.6 mg/l
Zinc, total	0.01 to 24.8 mg/l

Flows from the seeps are greatly reduced during the summer and some may completely stop. It is estimated that these seeps contribute 2 to 25 percent of the metals in Slickrock Creek.

o Tailings Piles and Waste Dumps

The sources along Slickrock contribute pollutants both during storm and normal rainfall events. The hematite pile along Slickrock Creek contributes about 1 percent of the metals in Slickrock Creek.

o Other Sources

The other sources of pollution along Slickrock Creek are the Brick Flat Bypass that flows down the mountain and enters the creek, subsurface drainage, and dissolution of metal-bearing sediment in the creek. It is estimated that these sources can contribute up to 5-30 percent of the metals in Slickrock Creek depending upon the time of year in which the discharges occur.

d) Spring Creek

The existing water quality in Spring Creek is presented on Table 6. The source of contamination in Spring Creek have been described in the Boulder Creek and Slickrock Creek sections.

In addition, there are probably sediment deposits within the streambed, as observed along Slickrock Creek, which also contribute to metals pollution.

It is not possible to fully assess the metal contribution of the sediments, but it is estimated it is relatively minor in relationship to the contribution from Boulder and Slickrock Creeks.

e) Keswick Reservoir and Sacramento River

The source of contamination in Keswick Reservoir are inflows from Flat Creek and Spring Creek and sediments deposited within the reservoir. The average water quality in the Sacramento River is presented in Table 7.

The Sacramento River above Keswick Reservoir already contains metals as shown in Table 7. After Flat Creek and Spring Creek enter the river in Keswick Reservoir, the concentration of metals are elevated up two to three times. Due to the relative low concentrations of metals and the variable flows from Keswick Reservoir, it is not possible to accurately estimate the metals contribution from Flat Creek and Spring Creek.

3. Environmental Impacts

Due to past and continuing releases of AMD to receiving waters, Boulder Creek, Slickrock Creek, Flat Creek and portions of Spring Creek are essentially devoid of aquatic life. During the RI, between 1,143 and 3,695 pounds per day of copper, zinc, plus cadmium were carried from the site into the Spring Creek Reservoir. Of this total, between 623 and 3,328 pounds per day of copper, zinc and cadmium were discharged into the Sacramento River. These releases occurred over a period that is best characterized as relatively dry winter conditions. The above totals can be expected to rise significantly during normal or above normal rainfall conditions.

Off-site, subsurface migration of contaminated groundwater does not appear to be a problem at this site. The hydraulics of the site are such that the mine workings act as a drain, drawing groundwater towards the mountain, and discharging it into adjacent surface waters.

TABLE 6: Spring Creek Water Quality

Parameter	ABOVE IRON MOUNTAIN		BELOW IRON MOUNTAIN	
	Average	Range	Average	Range
pH (units)	--	4.5 to 7.8	--	2.4 to 3.2
Cadmium, total, mg/l	--	<0.001 to 0.001	0.10	0.03 to 0.16
Copper, total, mg/l	0.06	0.03 to 0.10	1.94	0.97 to 2.74
Zinc, total, mg/l	0.12	0.07 to 0.15	12.5	3.25 to 17.4

Table 7

SUMMARY OF SACRAMENTO RIVER MONITORING

FEBRUARY 2, 1984, THROUGH JUNE 24, 1984

(Average of Detectable Values)[a]

Parameter (Ug/L, except as noted)	Sacramento River Below Shasta Dam	Sacramento River Above Spring Creek[b]	Sacramento River Below Keswick Dam	Sacramento River at Redding Intake	Sacramento River Below Keswick Dam[c] Average	Range
pH (range of units)	6.4 to 8.1	6.5 to 8.2	6.3 to 8.1	6.3 to 8.0	—	—
Conductivity (mmhos/cm)	97	94	94	81	—	—
Temperature	9.6	10.2	9.9	10.3	—	—
Cadmium, total	0.10	0.29	0.55	0.23	—	—
Cadmium, soluble	0.18	0.29	0.41	0.37	2.5	1.8 to 4.0
Copper, total	3.5	6.5	8.5	15.8	—	—
Copper, soluble	3.7	4.6	4.8	4.9	24	10 to 52
Iron, total	224	339	505	470	—	—
Iron, soluble	63	76	66	66	—	—
Sulfate (mg/L)	3.7	4.6	5.2	6.3	—	—
Zinc, total	14.8	24.6	37.0	37.4	—	—
Zinc, soluble	13.0	26.3	30.8	39.8	196	23 to 500

[a]Only values reported above the detection limits were averaged.

[b]Sampling site appears to be influenced by backeddies from Spring Creek.

[c]Concentrations monitored by RWQCB during three spill events at Spring Creek Reservoir--January 1978, January 1983, and March 1983.

Note: No identifiable reasons for higher soluble concentrations compared to total concentrations of some constituents.

4. Impacts on Aquatic Life

a) Introduction

While the occurrence of toxicity has been documented in the Sacramento River, it is extremely difficult to quantify the extent of the loss in a river the size of the Sacramento. The fishkills occur during the wet season when the waters are typically muddy. Even with clear water, the river is difficult to survey with widths as great as 300 feet, depths as great as 35 feet, and fast currents that carry dead fish downstream. The most difficult mortalities to observe in the river are the fish most sensitive to metal toxicity - the early life stages of salmon and steelhead. These sensitive salmonid lifestages live underneath the gravel as small "sac fry" or in the river as small 2-inch "swim-ups" that have emerged from their nests.

In addition to the occurrence of lethal toxicity, there are more frequent occurrences of sublethal toxicity that could act to reduce the overall productivity of the population. Effects such as reduced growth rates, physiological problems, and diminished immune response are known to occur due to exposure to heavy metals. In a recent report to the U.S. Bureau of Reclamation, the U.S. Fish and Wildlife Service estimated that the monetary value of the chinook salmon and steelhead trout runs produced upstream from the Red Bluff Diversion Dam is approxmately $33.7 million annually. In addition, the economic value of these fishery resources, with attainment of fishery management goals, is anticipated to increase to $72 million annually.

b) Discussion

Valuable fisheries resources, including migratory populations of salmon, steelhead and resident populations of trout in the Sacramento River are significantly impacted by the AMD from the Spring Creek basin and have experienced numerous instances of above normal mortality over the last 46 years. These incidents which, have been directly attributed to AMD from Iron Mountain Mine were the result of observed mortality of adult fish in the Sacramento River and calculated mortality of eggs and fry on the basis of copper, zinc, and cadmium levels measured in the River below Keswick Dam. Table 8 was developed by the California Department of Fish and Game (CDFG) and lists the documented fishkills. CDFG has indicated that the Fall run of chinook salmon in the upper Sacramento River has ranged from an estimated high of 400,000 in 1953 to a low of 22,000 with an average decline of 87 percent in the last 20 years; that the average run of salmon over a 20 year period showed a decline from 275,000 to 75,000 salmon. This decline is attributed to several causes including AMD from Iron Mountain Mine.

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TABLE 8

DOCUMENTED OCCURRENCES OF SALMON AND TROUT MORTALITIES IN THE SACRAMENTO RIVER ATTRIBUTED TO HEAVY METAL POLLUTION FROM SPRING CREEK DRAINAGE
SHASTA COUNTY

Date	Observation Location	Types of Mortalities Observed: Salmon Adult	Salmon Juvenile	Trout Adult	Trout Juvenile	Number of Mortalities Counted	Estimated Number of Mortalities	Method of Observation	Conditions in Sacramento River: Flow (cfs)	Clarity	Sacramento River Below Keswick Maximum Metal Concentrations (mg/l): Copper	Zinc
1940	Kenett Smelter Waste Pile					Unknown						
11/44	Balls Ferry	x				200	30% of spawning run	spot observation	3,000		0.061	---
Winter 1945	Balls Ferry		x					numerous cage tests			---	---
04/49	Balls Ferry		x		x	Unknown		inspect one mile of bank			0.04	0.65
04/22 1955	Redding Area		x			Hundreds		spot observations	5,000		---	---
11/22 1955	Keswick Dam	x	x			42		Keswick Fish Trap and bioassay of Spring Crk water	4,000	muddy	--- ---	--- ---
02/23 1956	Redding Area	x	x	x	x	Unknown		spot observation	27,000	muddy	---	---
01/19 1957	Redding Area		x			Unknown		spot observation	3,500		---	---
02/05 1957	Redding Area		x			Unknown		---	2,600	muddy	---	---
02/16-19/57	Redding Area		x			25		---	2,600		---	---
02/26 1957	Redding Area		x			250		---	12,000	muddy	---	---
09/26-30/57	Redding Area		x			25,000	---	survey 3 miles of one bank	7,500	muddy	---	---

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1/22 1955	Keswick Dam	x	x			42		Keswick Fish Trap and bioassay of Spring Crk water	4,000	muddy	--- ---	--- ---
2/23 1956	Redding Area	x	x	x	x	Unknown		spot observation	27,000	muddy	---	---
1/19 1957	Redding Area		x			Unknown		spot observation	3,500		---	---
2/05 1957	Redding Area		x			Unknown		---	2,600	muddy	---	---
2/16-.9/57	Redding Area		x			25		---	2,600		---	---
2/26 1957	Redding Area		x			250		---	12,000	muddy	---	---
9/26-0/57	Redding Area		x			25,000	---	survey 5 miles of one bank	7,500	muddy	---	---

According to the CDFG, the decline of the upper Sacramento River salmon and steelhead stocks represents a sizeable economic loss to the state due to the lost availability of these fish to the commercial and sport fishery. At times, the upper Sacramento River produced half of the state's Chinook salmon. Economic studies conducted by CDFG and the U.S. Fish and Wildlife Service have estimated that the continuing economic losses associated with the present depressed population levels of salmon and steelhead relative to the catch levels in the past have a net annual economic value ranging between \$30-\$40 million. CDFG believes that the incremental mortality caused by discharges from Iron Mountain Mine are responsible for a significant share of that economic loss.

Of particular concern is impact of AMD on populations of winter run chinook salmon, one of four genetically distinct populations of salmon in the river. According to the CDFG, the winter run population in the upper Sacramento River has declined precipitously in the past 20 years to the point where the National Marine Fisheries Service is evaluating a petition requesting that the winter run chinook be listed under the Endangered Species Act of 1973. The CDFG has apprised EPA that one of the priority actions that would be included in any winter run restoration or recovery effort is correcting the heavy metal pollution problem caused by Iron Mountain Mine. Additionally, the king salmon runs in the upper Sacramento River have experienced a 50 percent decline over the past 30-35 years, with heavy metal pollution from the Spring Creek basin being cited as one of the major responsible factors.

Because of the variations in the operation of the Shasta unit (Shasta Dam, Keswick Dam, Spring Creek Debris Dam, and the Spring Creek hydroelectric power plant), and unusual climatological conditions, there has not been any long-term undiluted spills and, thus, no observed mortality of adult fish in the Iron Mountain Mine area since 1969. There is, however, a shared concern among state and federal regulatory agencies that as competition for Shasta Lake water increases in the future, the U.S. Bureau of Reclamation may be held more accountable for ensuring that only the authorized uses of the water are allowed; this could result in the lack of adequate dilution water being made available to avert fishkills.

5. Potential Public Health Impacts

The degree of human risk associated with the AMD from the Iron Mountain Mine site depends on the nature and extent of exposure. The California Department of Health Services (Department), in an endangerment assessment prepared on August 22, 1984, for this project, discussed the types of exposure that represent a potential threat to public health. These included the following:

Dermal Contact: Near its source, the AMD contains sulfuric acid in concentrations that could cause serious eye injuries and skin irritation through direct exposure. Although the study area is located in rugged and remote terrain, the potential for human exposure cannot be ruled out. The area is located between two heavily used National Forest areas.

Areas adjacent to the mine property are frequently used for recreational purposes, especially for off-road vehicle use. The mine owners have complained of trespassing and vandalism problems on the site. The AMD is diluted as it enters Boulder Creek and Slickrock Creek and there is a less serious risk with regard to dermal contact with increased distance from the source.

Ingestion of Water: The potential for direct ingestion of AMD in the upper study area is considered small for two reasons: a) once the AMD enters the creeks, there is a discoloration associated with the precipitation of iron, and b) the remoteness of most of these areas limits access.

Cadmium concentrations measured at the Redding raw water intake have not exceeded the drinking water standards. A potential public health threat does exist due to the elevated concentrations of metals in the Sacramento River. Levels of cadmium in the River have approached and occasionally have exceeded the proposed EPA drinking water standard of .005 mg/l.

Ingestion of Fish: Ingestion of fish taken from Keswick Reservoir does not appear to represent a significant public health threat according to an analysis which expanded the endangerment assessment prepared by the Department of Health Services. However, the Department indicates that the long term risk from the bioaccumulative toxin, cadmium, should not be underestimated. The Department estimates that 50 percent of the body burden of cadmium is located in the liver and kidney of fish, with another 50 percent distributed across other tissues. Humans also accumulate cadmium in the liver and kidneys over their lifetime. It is felt that, without remediation, mine effluent will continue to be deposited in sportfishing areas of the Sacramento River and the concentration of cadmium in fish will continue to be elevated above normal levels.

6. Impacts on Public Welfare

Shasta Dam was constructed under the authority of Public Law 84-386, as part of the Trinity River Division, Central Valley Project. This law created several specific uses of Shasta Lake water, including the generation of hydroelectric power, water sales to farmers, and use as a drinking water supply. Shasta Lake also has a recreational value associated with tourism, boating, fishing, and swimming.

Release of Shasta Lake waters for pollution control in the Iron Mountain Mine area is <u>not</u> an authorized use of these waters. Nevertheless, since the construction of the Shasta Dam/Keswick Dam/Spring Creek Debris Dam water management system, Shasta Lake waters have been, and continue to be released for this purpose, when waters can be provided without adverse impacts to other project requirements. By controlling the release of these waters the U.S. Bureau of Reclamation (Bureau) has assisted other federal and state agencies, in promoting fishery resources in the Sacramento River.

Although it is difficult to quantify the exact value of Shasta Lake water, the Bureau has estimated the revenue that would be lost by releasing Shasta Lake water for pollution control. This was accomplished through the use of a mathematical water model that assumed that water that wasn't being released for pollution control would be sold for municipal and industrial purposes. Based on the Bureau's analysis, it was estimated that meeting less stringent standards (the original water quality standards that were in effect prior to the state adopting the existing water quality standards) in the Sacramento River would result in an annual loss in revenue from the U.S. Treasury of about $32 million, and that fish saved by releasing this additional dilution water would have an annual value of $1.4 million. Meeting the proposed Superfund metals levels, which are substantially lower, would cost about $456 million in dilution releases, with fish savings of about $9.6 million per year. Without remediation in the form of source control and treatment, releases of Shasta Lake water will be required until such time as Iron Mountain Mine ceases to discharge AMD.

V. ENFORCEMENT ANALYSIS - Confidential

(See Attachment)

VI. <u>ALTERNATIVES EVALUATION</u>

A. Introduction

The major objective of the feasibility study was to evaluate remedial alternatives using a cost-effective approach consistent with the goals and objectives of CERCLA. A cost-effective remedial alternative is defined in the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) 40 CFR §300, et.seq. as the alternative that effectively mitigates and minimizes threats to and provides adequate protection of public health and welfare and the environment. Except as provided in Section 300.68(i)(5), this requires the selection of a remedy that attains or exceeds applicable or relevant and appropriate federal public health and environmental requirements that have been identified for the specific site. In selecting the appropriate extent of remedy, EPA is directed to consider cost, technology, reliability, administrative and other concerns, and their relevant effects on public health and welfare and the environment.

The feasibility study process included the following steps: (1) identification of general response actions, (2) identification of target clean-up levels, (3) assembly of the universe of technologies relevant to the response actions, (4) retention of the surviving technologies as component actions, (5) assembly of the component actions into combined alternatives, (6) initial screening of the combined alternatives, and (7) detailed analysis of surviving combined alternatives. Nine combined alternatives (CA-1 to CA-9) underwent very detailed analysis. Three alternatives were considered in less detail and were included in the final alternatives matrix: Alternatives CA-10 ($1.4 billion), CA-11 ($350 million) and CA-12 ($263 million). The feasibility study results are presented in more detail in the following paragraphs.

Based on site background information and the nature and extent of the problems from the technical investigation to date, the key general objectives for the Iron Mountain Mine site were:

- To minimize off-site contaminant migration via surface water runoff and seepage, and
- To mitigate impacts and minimize the migration of contaminants that have already moved from the site through receiving waters.

The two areas targeted for remediation and selected general response actions were:

Areas of Remediation	General Response Action
Ore bodies and underground mine workings	No action, recovery, treatment, source control, and disposal
Surface water	No action, water management, treatment, and disposal.

The contaminants of primary concern at the Iron Mountain Mine site are copper, cadmium, and zinc because: a) these contaminants have been detected at high levels at the source and in surface waters receiving discharges from Iron Mountain Mine, b) acute dosages of these contaminants have been found to result in fish kills; sub-lethal impacts have, among other things, resulted in reduced rates of growth and accumulations of metals in fish tissues; and c) even when toxic levels are not reached, these metals act to depress the overall productivity of life in Keswick Reservoir and the Sacramento River.

B. Site-Specific Action Levels

Three sets of target clean-up levels were considered as primary cleanup objectives for Iron Mountain Mine:

1. Implement remedial actions to achieve the following EPA Water Quality Criteria for Protection of Aquatic Life below Keswick Dam:

   Copper: 5.4 ug/l
   Zinc: 47.0 ug/l;
   Cadmium: 0.55 ug/l

2. Meet Regional Board Basin Plan Objectives for copper, cadmium and zinc in the Upper Sacramento River:

   Copper: 5.6 ug/l
   Zinc: 16.0 ug/l;
   Cadmium: 0.22 ug/l

   These objectives are based on a series of intensive studies conducted by the CDFG. According to CDFG, implementation of remedial activities that meet these objectives would provide safe levels having no chronic or acute effect on aquatic life in the Upper Sacramento River.

3. Meet background levels (established by the water quality upstream of the confluence of Spring Creek and the Sacramento River):

   Copper: 3.5 ug/l
   Zinc: 14.8 ug/l
   Cadmium: .1 ug/l

The secondary objective is to reduce the metals loading from the Iron Mountain Mine site to receiving waters.

C. Technology Development

A variety of technologies was examined with regard to technical feasibility, degree of public health protection afforded, environmental impact, institutional concerns, and cost.

The applicable technologies identified were then combined to form remedial action alternatives that addressed source control and treatment of AMD at the mine and surface water management.

Preferred technologies for the various components that addressed source control and water management are identified in Table 9.

D. Components for Detailed Analysis

The following discussion describes the components that were later combined into alternatives (see Table 10). Table 11 presents the technical, environmental, institutional and other considerations for each of the components (#1 through #11).

Component #1. Solution Mining (Proposed by IMMI)

Toward the end of the RI/FS, Iron Mountain Mine, Incorporated (IMMI) submitted a concept for a proposed metals recovery operation at Iron Mountain Mine. This proposal was developed independent of EPA's feasibility study by consultants for IMMI. This proposal included the in situ leaching of the sulfide orebody to extract copper, zinc, iron, and precious metals, and the recovery of the base metals as industrial and agricultural chemicals.

The basic principle of the IMMI proposal is to seal the Richmond and Lawson portals, recirculate AMD back into the mountain and draw off 2,000 gpm of concentrated acid mine water from in situ leaching, and treat it at a copper extraction plant. An acidified 1,800 gpm stream would be recycled for reinjection into the orebody to enhance metal leaching. A 200 gpm bleed stream is treated in the metal salts recovery plant and a wastewater treatment plant prior to discharging to receiving waters or irrigation.

Component #2. Partial Capping

The purpose of capping and constructing drainage ditches around cracked and caved ground areas above the Richmond orebody is to reduce the water available for generation of AMD by intercepting surface water and directing it away from the orebody. This source control method is applicable primarily to the Richmond-Complex orebody as this is the only source that shows significant contribution from surface water inflow. Cracked ground, caved ground, and other known primary conduits for inflow would be surface-plugged and sealed to reduce the rapid inflow of water into these areas. Surface water would be intercepted by a system of lined ditches and directed away from the orebody to reduce the potential of surface water finding a path of rapid inflow.

Table 9. Available Technologies

General Response Action	Technologies
OREBODIES AND MINE WORKINGS	
No Action	No action
Recovery	Mine the orebody using open pit, underground, or in situ methods
Treatment	In situ methods without metals recovery, and the use of surfactants or other inhibiting agents groundwater barrier walls, groundwater interception, pumping, and revegetation of disturbed areas. Injection of Low-density concrete in underground mine workings.
Disposal	Landfill
SURFACE WATER	
No Action	No action
Water Management	Transbasin stream diversion (pipe, open channel, flume), local stream diversion, enlarge existing storage, construct new storage, and modify CVP operating plan
Treatment	Precipitation (utilizing lime/ limestone, sodium hydroxide, soda ash), biological neutralization, bogs, sulfide precipitation, starch xanthate treatment, clarifier thickener, aeration, chemical oxidation, biochemical oxidation, electroflocation, ionic flotation, carbon adsorption, solvent extraction, sodium aluminate, copper cementation, electrowinning, filtration, ion exchange, reverse osmosis, electrodialysis
Disposal (AMD)	Solar evaporation, deep well injection, controlled release, and deep water injection
Disposal (Solids)	Landfill (on or offsite), solids disposal in mine workings

Table 10. Components for Detailed Analysis

SOURCE CONTROL

- Partial capping
- Complete capping
- Groundwater interception
- Injection of Low Density Cellular Concrete in underground Mine Workings

TREATMENT

- Treatment of the three major sources
- Treatment of the five major sources
- Treatment of five major sources and other sources in Slickrock Creek
- Treatment of the five major sources plus other sources in Slickrock Creek and Boulder Creek

WATER MANAGEMENT

- Diversion of upper Spring Creek to Flat Creek
- Diversion of South Fork Spring Creek to Rock Creek
- Enlargement of Spring Creek Debris Dam
- Diversion of Upper Slickrock Creek around tailings piles

TABLE 11
Technical, Environmental and Institutional Considerations for Remedial Action Components

Component Alternative	Technical Concern	Environmental Concern	Institutional Concern	Other Concerns
SOURCE CONTROL				
Complete Capping	This alternative is expected to be 90 percent effective in intercepting infiltration and 50 percent effective in reducing AMD from Richmond portal. Cannot accurately predict overall effect on metals reduction. No serious constructability problems, but the removal of all vegetation from the site may cause permitting problems.	Reduced metals from IMM and improved water quality in the Sacramento River. Reduced vegetation and wildlife habitat.	No major impact from institutional requirements.	Improved protection of City of Redding drinking water supply.
Partial Capping	Proven technology, but innovative for this application. Difficult to accurately predict its effectiveness in reducing AMD from the Richmond portal.	Potential terrestrial disturbance during construction.	No major impact from institutional factors.	This alternative is estimated to be one of the most effective source control alternatives. This alternative minimizes waste at the source.
Injection of low-density cellular concrete	This technology is not proven in this application. This alternative would be equivalent to an experiment since it is not possible to accurately predict its effectiveness without implementing the alternative. However, anticipated hydrogeologic studies and pilot studies would reduce the uncertainties associated with its implementation. There would be a risk that it would be much less effective than the assumed effectiveness used in this report. There is also some uncertainty with regard to long-term reliability of the LDCC in contact with the AMD and the potential of new sources of AMD discharge as the water table rises.	As the water table rises, new sources of discharges from the orebody could affect vegetation and wildlife in areas presently not affected.	No major impact from institutional factors.	The risk of uncertainty and the effectiveness and reliability must be compared to potential reduction in O&M costs. The treatment alternatives have significant O&M costs beyond the 30-year evaluation period for this study. This alternative minimizes waste at the source; however, it could have an effect on potential future mining of the orebody.

TABLE 11
Technical, Environmental and Institutional Considerations for Remedial Action Components

Component Alternative	Technical Concerns	Environmental Concerns	Institutional Concerns	Other Concerns
Groundwater Interception	This alternative is expected to be 90 percent effective in intercepting groundwater. Cannot predict accurately the overall effect on either water or metals reduction. No serious constructability problems. High level of safety required for work in underground tunnels.	Improved water quality in the Sacramento River resulting in improved aquatic habitat.	No major impact from institutional requirements.	Improved protection of City of Redding drinking water supply.
TREATMENT				
Five Major Sources	Utilizes proven technology. No serious constructability problems.	Improved water quality in the Sacramento River resulting in improved aquatic habitat.	Sludge generated from this process may be considered a hazardous waste and require extensive permitting.	Improved protection of City of Redding's drinking water supply.
Five Major Sources Plus other Slickrock Sources	Utilizes proven technology. No serious constructability problems.	Improved water quality in the Sacramento River resulting in improved aquatic habitat.	Sludge generated from this process may be considered a hazardous waste and require extensive permitting.	Improved protection of City of Redding's drinking water supply.
Five Major Sources plus other Slickrock and Boulder Sources	Utilizes proven technology. No serious constructability problems.	Improved water quality in the Sacramento River resulting in improved aquatic habitat.	Sludge generated from this process may be considered a hazardous waste and require extensive permitting.	Improved protection of City of Redding's drinking water supply.

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Technical, Environmental and Institutional Considerations for Remedial Action Components

Component Alternative	Technical Concern	Environmental Concern	Institutional Concern	Other Concerns
Treatment of three major sources (Richmond portal, Lawson portal, and Old No. 8 seep) with lime/limestone treatment	Proven technology.	Disturbance or loss of aquatic and terrestrial organisms and habitat during construction.	Sludge generated from this process may be considered hazardous waste and require extensive permitting.	This alternative would require perpetual O&M costs for handling sludge beyond the 30-year economic period used in this analysis. Does not minimize waste at the source.
WATER MANAGEMENT				
Diversion of Upper Spring Creek Diversion of South Fork Spring Creek.	Utilizes proven technology which involves no mechanical equipment. No serious constructability problems, but increased flooding potential along Flat Creek may cause permitting problem.	Improved water quality in Flat Creek and the Sacramento River resulting in enhancement of aquatic habitat.	Property acquisition may be required downstream on Flat Creek if property along creek is flooded.	Potential flooding in Flat Creek. Increased metals concentration in Spring Creek and related increased hazards associated with human contact. However, there is an overall benefit to public health aspects of the City of Redding drinking water.
Diversion of upper Slickrock Creek around tailings			Property acquisition may be required downstream on Rock Creek if property along creek is flooded.	
Enlargement of Spring Creek Debris Dam	Utilizes proven technology which involves no mechanical equipment. No serious constructability problems, but will require USBR approval.	Improved water quality in the Sacramento River.		

The caved ground areas would be filled and sloped to maximize runoff. A total of five caved ground areas would be filled; this will require a total fill quantity of approximately 40,000 cubic yards of material. To reduce vertical infiltration into caved ground areas, the areas would be filled and graded to drain using a filter material and low permeability layer.

Component #3. Complete Capping

This component involves capping approximately 15 acres overlying the Richmond orebody. The alternative would require stripping and grubbing of some of the existing vegetation, filling of the caved and cracked ground, some regrading of the site to limit slopes where possible, and construction of benches to divert water to adjacent drainages. A soil-cement surface barrier would then be applied to the area.

The six caved ground areas, totaling approximately 2 acres, would be filled with cobble- to sand-sized materials prior to applying the soil-cement. Two cracked ground areas would be filled with a slush-type grout and cobble- to sand-sized materials, with a low-permeability seal at the ground surface.

The lower portion of Brick Flat Pit would be filled similar to the caved ground areas to allow gravity drainage of water from the pit area.

Interception ditches and drains would be provided to intercept surface water and divert it away from areas where the orebody is exposed to surface runoff.

Component #4. - Ground Water Interception

In this component, groundwater moving toward the Richmond orebody would be intercepted by a tunnel and drill holes on either side of the orebody. Through gravity flow, the water would then be conveyed to Boulder Creek. Approximately 1,250 feet of the existing Richmond tunnel would be rehabilitated and used as the access tunnel for constructing the two new tunnels on either side of the orebody. These new tunnels would be approximately 7 feet in diameter and 1,600 feet in length.

A vertical system of drill holes would be installed approximately every 50 to 100 feet along the two new tunnels and would act as groundwater interceptors.

Component #5. Injection of Low-Density Cellular Concrete Into Underground Mine Workings

This component consists of filling the underground mine workings (UMW's) with a low-density cellular concrete (LDCC) to eliminate or reduce the formation of AMD. This objective could be met by LDCC injection if exposed ore could be sealed in the UMW's or if discharge could be reduced sufficiently to raise the groundwater table above the orebody, thereby minimizing available oxygen for the formation of AMD.

In developing this component, it was assumed that a concrete batch plant and materials storage facility would be constructed near the Richmond portal. Stockpiled at the site would be cement, chemicals for producing a low-density concrete (this chemical is a foaming agent which causes the concrete to expand and therefore reduces its density), and aggregate. The aggregate for the LDCC would be composed of Minnesota Flats tailings, available onsite hematite material, and waste rock and slide material from the Big Seep. This would reduce the cost for aggregate material and also reduce existing sources of surface runoff pollution. Water containing AMD would be conveyed to the batch plant, where it would be neutralized and used in the manufacture of the LDCC.

As the LDCC is produced, it will be pumped into the mine workings and allowed to solidify. This is intended to coat the exposed ore and plug the UMW's, which could bring the water table back to historical elevation, and eliminate or reduce AMD formation. Rehabilitation of the Richmond workings would be required to provide access needed to effectively inject the LDCC. Rehabilitation of the Hornet workings and others may also be necessary.

It is expected to take two years, operating 24 hours per day, to fill the workings with LDCC.

<u>Component #6. Treatment</u>

- Sub-Component 6 (a) Treatment of AMD from Three Major Sources

This component consists of collecting AMD from the Richmond portal, Lawson portal, and Old No. 8 seep, and conveying it to a lime/limestone treatment plant for treatment. This component assumes that the sludge produced from the treatment plant would be dewatered and taken to Brick Flat Pit (BFP) for disposal. It is estimated that BFP can accomodate dewatered sludge produced by treating the three major sources over a 30-year period.

For ease of transporting sludge to BFP, the lime/limestone treatment plant would be sited at the old processing facility near the Richmond portal. AMD from the Old No. 8 seep may or may not have to be pumped to the treatment plant, depending on final site layout and elevations.

BFP would be modified with an embankment to provide storage of the sludge produced from the treatment process. The walls of the pit would be coated to form a relatively impervious liner.

In conjunction with the treatment plant construction and modifications to BFP, road improvements to these sites will have to be constructed.

•Sub-Component 6 (b) Treatment of AMD from Five Major Sources of Pollution

AMD from the five major sources (Richmond portal, Lawson portal, Big Seep, Old No. 8 seep, and Brick Flat Pit diversion) would be collected and transported by gravity to the treatment plant. The maximum flow for this alternative is estimated to be 4,000 gpm. The expected overall removal of metals leaving the site with this alternative is 72 percent of copper and 86 percent of zinc and cadmium.

Small diversion structures would be constructed at Big Seep and the Brick Flat Pit diversion. Flows from these five sources would be combined into a PVC pipeline, which would be buried along the route of the existing access road and transported approximately 9 miles to the treatment plant located on 90 acres of land immediately adjacent to the Sacramento River.

The neutralization treatment process consists of the following units:

1. The addition of limestone to the AMD to increase the pH to 4.

2. Fifteen acres of first-stage settling lagoons to remove sludge.

3. The addition of lime to raise the pH to 8.5. The addition of air for the oxidation of soluble ferrous iron to insoluble ferric iron.

5. A heavy solids separator, together with 14 acres of second-stage solids lagoons for sludge removal.

The lagoons would be designed to allow the sludge to dry during the summer months. The remaining solids would then be hauled to either a Class I or Class II landfill constructed adjacent to the treatment plant.

•Sub-Component 6 (c) Treatment of AMD from Five Major Sources Plus Other Slickrock Sources

The component is essentially the same as Alternative 7 (b) with the exception that the sources on Slickrock Creek will also be collected and treated with the five major sources.

The collection system on Slickrock Creek would consist of an upper diversion dam which bypasses clean water around the reach of the creek that is impacted by the other sources including seeps, slide debris, and tailings piles.

A second diversion dam would be constructed downstream of the other sources to collect the flow from Big Seep, Old No. 8 Mine seep, and Brick Flat Pit diversion, together with the other sources. This AMD would flow by gravity and would be combined with the piped flows from Richmond portal and Lawson portal. The combined flow would then be routed to a lime/limestone treatment plant.

The maximum hourly flow for this alternative is estimated to be 42,000 gpm under 1978 conditions. This would require that the transport pipeline and limestone and lime treatment structures be enlarged above those estimated for Alternative 5. The size of the sludge lagoons would remain approximately the same. The expected overall removal of metals from the site with this alternative is 86 percent of copper and 93 percent of zinc and cadmium.

- Sub-Component 6(d) <u>Treatment of AMD from the Five Major Sources Plus Other Boulder and Slickrock Sources</u>

With this component, the five major sources and all other sources on Boulder Creek and Slickrock would be collected and treated. Upper diversion dams would be constructed on both Slickrock and Boulder Creeks to divert clean water around the areas of the creeks that are being contaminated by the other sources.

Downstream diversion dams would be constructed to capture and divert the remaining flows in the streams. The flows would be combined and would flow by gravity to the treatment plant.

The maximum hourly flow for this alternative is estimated to be 110,000 gpm under 1978 conditions. As with Alternative T-1b, this will require increasing the size of the pipeline and the treatment plant structures. It is expected that the overall removal of metals from the site with this alternative would be essentially 100 percent.

- Sub-Component 6 (e) <u>Treatment of AMD from the Three Major Sources with Copper Cementation</u>

With this component, the three major sources of pollution (Richmond portal, Lawson portal and the Old No. 8 mine seep) would receive copper cementation treatment. Copper cementation is an oxidation-reduction reaction whereby solvated (in solution) copper ions are exchanged for elemental iron (usually provided as scrap iron). This scrap iron, preferably well shredded to obtain good contact with the liquid waste stream, is placed in a basin large enough to produce fairly quiescent conditions. As the wastewater is passed through the basin, iron is dissolved into the stream and a copper sludge settles out. This process is currently being practiced at Iron Mountain Mine and is achieving good recovery of copper (as high as 95 percent plus removal in one of the cementation plants).

Component #7. Diversion of Upper Spring Creek

This component would reduce flow into SCDD by diverting upper Spring Creek to Flat Creek. A 16-foot-high, 100-foot-long, rock-filled diversion dam would be built on Spring Creek near Minnesota Flats to divert up to 800 cfs of flow.

An 8-foot-diameter tunnel, with a hydraulic capacity of approximately 800 cfs, would be constructed on the upstream side of the dam to divert the flow into the Flat Creek watershed. The length of this tunnel would be approximately 600 feet. A chute and energy dissipator would be constructed between the diversion and the point of discharge into Flat Creek.

Component #8. Diversion of South Fork Spring Creek

This component would reduce flow into SCDD by diverting the South Fork of Spring Creek (SFSC) to Rock Creek. To accomplish this, a 10-foot-high, 60-foot-long diversion structure would be built on SFSC. About 4,000 feet of 54-inch conduit would carry the diverted water to Rock Creek. The hydraulic capacity of the diversion system would be 250 cfs.

Component #9. Enlargement of Spring Creek Debris Dam

The existing Spring Creek Debris Dam would be enlarged at its present site. The present storage capacity of the dam is 5,800 acre-feet. This would be increased to a volume of between 7,000 acre-feet and 23,000 acre-feet depending on which cleanup objective is selected.

Component #10. Upper Slickrock Creek Diversion Around Tailings Piles

The purpose of this diversion is to reduce the volume of flow from the Big Seep pollution source. It is believed that as Slickrock Creek flows over and through the pile of slide debris that fills the canyon above the Big Seep area, a significant portion of the flow enters the loose slide material and reappears in the Big Seep area. Analysis of the Big Seep hydrograph has led to the conclusion that a significant reduction in the flow and pollution load from Big Seep could be achieved by intercepting and diverting Upper Slickrock Creek before it comes into contact with the slide debris.

This component would involve a diversion structure, an 18-inch PVC pipeline, and an energy dissipator at the end of the pipeline. Upper Slickrock Crek flow would be diverted around the slide area to the lower reach of Slickrock Creek.

A numerical water quality model was used to determine if any of the individual components could achieve either California Basin Plan Objectives or EPA Water Quality Criteria for Protection of Aquatic Life below Keswick Dam. The model used a mass balance approach to account for heavy metals as they are carried in the streams (Boulder Creek, Slickrock Creek, and Spring Creek) through Spring Creek Reservoir and eventually to Keswick Reservoir. The model regulated discharges from Spring Creek Reservoir such that when the discharge is mixed with Sacramento River water released from Shasta Lake, water quality objectives are met below Keswick Dam.

The results from the operation of the model indicated that the aforementioned components generally could not achieve either set of water quality objectives below Keswick Dam (or points upstream) if implemented individually. There are two exceptions, however. Conceivably, the Spring Creek Debris Dam could be enlarged to such a size that the objectives could be met through flow equalization alone. Or, the objectives could be met by using the Spring Creek Reservior as a collection basin and treating all liquids in it by lime neutralization. This latter approach could achieve background levels for metals below Keswick Dam at an estimated cost of $263 million. Treatment of the liquids in the Spring Creek Reservior will be carried forward as an alternative. Varying the capacity of the Spring Creek Reservior by varying the height of the dam will be carried forward as a component of many of the alternatives to be considered. It was felt that varying the size of the Spring Creek Debris Dam should not stand alone as an alternative because this would provide only dilution of the AMD, with no source control or treatment and with no reduction of total metals loading into the Sacramento River.

E. Description of Combined Remedial Action Alternatives

The previously described components were assembled into combined alternatives for more detailed analysis. Nine alternatives (CA-1 through CA-9) underwent very detailed analysis. Three more alternatives (CA-10 through CA-12) underwent a less detailed analysis. The proposal submitted by the site owner to establish a solution mining operation at the site was screened out in the Feasibility Study because it had not been developed to the point where EPA could determine the technical feasibility and economic viability of the project. In addition, the project did not demonstrate compliance with all applicable, relevant and appropriate federal and state requirements, and a site closure plan had not been developed.

The remedial action alternatives evaluated in the Feasibility Study and the Addendum to the Feasibility Study are:

(CA-1) Diversion of upper Spring Creek to Flat Creek, diversion of South Fork Spring Creek to Rock Creek, complete capping above the Richmond Orebody, groundwater interception, and copper cementation.

(CA-2) Diversion of upper Spring Creek to Flat Creek, diversion of South Fork Spring Creek to Rock Creek, complete capping, groundwater interception, and treatment.

(CA-3) Diversion of upper Spring Creek to Flat Creek, diversion of South Fork Spring Creek to Rock Creek, and treatment.

(CA-4) Complete capping, groundwater interception, and treatment.

(CA-5) Enlargement of SCDD, diversion of upper Spring Creek to Flat Creek, and diversion of South Fork Spring Creek to Rock Creek.

(CA-6) Enlargement of SCDD, diversion of upper Spring Creek to Flat Creek, diversion of South Fork Spring Creek to Rock Creek, and copper cementation for flows from Richmond portal, Lawson portal, and Old No. 8 seep.

(CA-7) Enlargement of SCDD, diversion of upper Spring Creek to Flat Creek, diversion of South Fork Spring Creek to Rock Creek, complete capping above Richmond orebody, ground water interception, and copper removal from Richmond portal, Lawson portal, and Old No. 8 flows using copper cementation.

(CA-8) Treatment of AMD from the Richmond portal, Lawson portal, and Old No. 8 seep with lime/limestone treatment, complete capping, Upper Spring Creek diversion, South Fork Spring Creek diversion, Upper Slickrock Creek diversion, and enlargement of Spring Creek Debris Dam. This alternative includes disposal of dewatered sludge from the treatment process in Brick Flat Pit.

(CA-9) Filling all the major mine workings (Hornet, Richmond, No. 8, and Old Mine orebodies) with LDCC, partial capping, Upper Spring Creek diversion, South Fork Spring Creek diversion, Upper Slickrock Creek diversion, treatment of the remaining AMD from the three major sources by lime/limestone neutralization, and disposal of dewatered treatment sludge in Brick Flat Pit, and enlargement of Spring Creek Debris Dam.

(CA-10) Excavation of the upper portions of the orebody, waste rock, and tailings piles and off-site disposal in a lined facility, removal of contaminated sediments in the affected tributaries and the Spring Creek Reservoir, and the removal of the Minnesota Flats Tailings pile.

(CA-11) Removal of the Minnesota Flats Tailings pile and bottom sediments in the tributaries and Spring Creek Reservoir with off-site disposal; collection of the leachate from all point and non-point sources, and treatment of the collected leachate with lime neutralization. This alternative includes construction of a nearby RCRA-type sludge disposal facility.

(CA-12) Utilization of the Spring Creek Reservoir as a collection basin for all point and non-point sources and treatment of all liquids passing through the reservoir with lime neutralization.

- NO ACTION ALTERNATIVE

The ability to successfully discharge contaminated water from Spring Creek Reservoir to meet dilution requirements depends on several factors. The timing of the storms occurring on Spring Creek watershed, the available storage in Spring Creek Reservoir when storms occur, and the available dilution water being released from Shasta Lake are all factors that determine whether or not contaminated water from Spring Creek will spill. Therefore, historical data from four different years were used to evaluate the effectiveness of the proposed alternatives. The year 1978 was selected because above average runoff occurred on the Spring Creek watershed and there was little dilution water available from Shasta Lake while water was being stored to replenish lost water supplies following two years of drought; this year was identified as the 'worst case' year. The years 1980 and 1981 were selected because total runoff from the Spring Creek watershed was about average for the period of record from 1967 to 1984. The 1983 water year was used because that year had the highest runoff volume into Spring Creek Reservoir for the period of record. In all cases, the data factored into the water quality model reflected the U.S. Bureau of Reclamation's (Bureau) operation plan for Shasta Lake for each of the four case years. The alternatives were analyzed assuming that the Bureau would continue to operate according to its plan for Shasta Lake. The alternatives do not necessarily require a modification of the Bureau's operating plans.

Alternatives CA-1 through CA-7 were evaluated for four different water years (described above) and two different sets of aquatic water quality criteria (also previously described); CA-8 and CA-9 were analyzed for two water years and two sets of aquatic water quality.

The point of compliance with the water quality criteria for alternatives CA-1 through CA-9 is below Keswick Dam (the most upstream point to which salmon can migrate).

Alternative CA-10 should achieve aquatic water quality criteria everywhere from the site proper downstream. Alternative CA-11 should achieve water quality criteria below the proposed collection dams, constructed on Boulder Creek and Slickrock Creek, but it would leave the tributaries near Iron Mountain Mine devoid of aquatic life. Alternative CA-12 should achieve water quality criteria below Spring Creek Reservoir, but it would leave the reservoir and points upstream devoid of aquatic life.

F. Alternative Screening

According of the NCP, alternatives must be developed for each of the following five categories "to the extent that it is both possible and appropriate".

a) Alternatives for treatment or disposal at an off-site RCRA permitted facility approved by EPA.

b) Alternatives that attain applicable and relevant federal public health or environmental standards.

c) As appropriate, alternatives that exceed applicable and relevent public health or environmental standards.

d) Alternatives that do not attain applicable or relevant public health or environmental standards but which will reduce the likelihood of present or future threat from the hazardous substances. This must include an alternative that closely approaches the level of protection provided by the applicable or relevant standards and meets CERCLA's objectives of adequately protecting public health and welfare and the environment.

e) A no-action alternative.

The following is a description of how each of the above combined remedial action alternatives and the total removal of the source alternative fits into each of the five categories:

a. Offsite disposal at a RCRA-approved facility
The only alternative that fulfilled these requirements is CA-10.

b. Alternatives fully complying with all applicable or relevant standards, guidance, and advisories

CA-10. For all :racticable purposes, this is the same alternative as tne one that exceeds all applicable and relevant and appropriatate standards. Due to data limitations, it was not possible to identify what lesser portion of the orebody and other sources would need to be removed to exactly meet all standards, guidance, and advisories. This would require mapping the fractures, faults, and all pathways of migration through the mineralized zone and determining the volume, quality, and location of contaminants discharged to receiving waters on a seasonal basis. This would involve an extensive underground exploratory program lasting several years at an estimated cost of about $5 million. It should be stressed that at the start of the Remedial Investigation (RI) in 1983, the RI/FS guidance had not clearly delineated that alternatives be developed for each of the five categories; there was, therefore, no perceived need to conduct an RI of such a comprehensive scope.

c. Alternatives exceeding all applicable or relevant standards, guidance, and advisories.

CA-10.

d. Alternatives meeting all CERCLA goals, but not fully complying with all applicable or relevant standards, guidance and advisories.

Alternatives CA-2 through CA-9 and CA-11 and CA-12. Combined alternatives CA-5 through CA-9 vary on their ability to meet appropriate and relevant environmental standards based on the amount of storage provided by the enlargement of the Spring Creek Reservoir.

e. A no-action alternative.

The No-Action alternative was carried through the Feasibility Study as a baseline to compare remedial action alternatives.

The combined alternatives matrix (Table 12) describes each alternative, presents the capital and operation costs to meet EPA standards for 1978 and the anticipated benefits of each alternative.

Table 12

Combined Alternatives Matrix[5]

ALTERNATIVE		COST ($ Million) Capital	COST ($ Million) O&M (Present Worth)	ANTICIPATED BENEFIT EPA Water Quality Criteria (EPAWQC) State Basin Plan Objectives (SBPO)
No Action		____	____	No benefit; continued degradation of water quality
CA-1	Upper Spring Creek and South Fork Spring Creek diversions combined with complete capping above the Richmond orebody, groundwater interception, and copper cementation	____	____[1]	Achieves EPAWQC below Keswick Dam for water years 1980 and 1983 and SBPO for water year 1980 only. Does not achieve EPAWQC or SBPO for water years 1978 or 1981.
CA-2	Upper Spring Creek and South Fork Spring Creek diversions, combined with complete capping above the Richmond orebody and groundwater interception combined with treatment	80.3	20.8[2]	Achieves EPAWQC and SBPO below Keswick Dam for all four water years considered.
CA-3	Upper Spring Creek and South Fork Spring Creek diversions combined with treatment	69.4	20.2[2]	Achieves EPAWQC and SBPO below Keswick Dam for all four water years considered.
CA-4	Complete capping above the Richmond orebody and groundwater interception combined with treatment	129.3	22.8[2]	Achieves EPAWQC and SBPO below Keswick Dam for all four water years considered.
CA-5	Enlargement of Spring Creek Debris Dam to 23,000 acre-feet, combined with uppper Spring Creek and South Fork Spring Creek diversions	37.4	0.6[2]	Achieves EPAWQC and SBPO below Keswick Dam for all four water years considered.
CA-6	Enlargement of Spring Creek Debris Dam to 23,000 acre-feet, combined with upper Spring Creek and South Fork Spring Creek diversions, and copper cementation	30.6	1.1[2]	Achieves EPAWQC and SBPO below Keswick Dam for all four water years considered.

Table 12 (Continued)

	ALTERNATIVE	COST ($ Million) Capital	COST ($ Million) O&M (Present Worth)	ANTICIPATED BENEFIT EPA Water Quality Criteria (EPAWQC) State Basin Plan Objectives (SBPO)
CA-7	Enlargement of Spring Creek Debris Dam to 18,000 acre-feet, combined with upper Spring Creek and South Fork Spring Creek diversions, copper cementation, complete capping above the Richmond orebody, and groundwater interception	40.9	1.9[2]	Achieves EPAWQC and SBPO below Keswick Dam for all four water years considered.
CA-8	Treatment of Richmond portal, Lawson portal, and Old No. 8 with lime/limestone; total capping; upper Slickrock Creek diversion; upper Spring Creek diversion; South Fork Spring Creek diversion; and enlargement of Spring Creek Debris Dam (if needed)	42.3	13.0[2]	Achieves EPAWQC and SBPO below Keswick Dam for all four water years considered.
CA-9	Injection of low-density cellular concrete into old mine workings (Hornet, Richmond, Old Mine, and Old No. 8); partial capping; upper Spring Creek diversion; upper Slickrock Creek diversion; South Fork Spring Creek diversion; and enlargement of Spring Creek Debris Dam (if needed)	68.1	4.1[2]	Achieves EPAWQC and SBPO below Keswick Dam for all four water years considered.
CA-10	Excavation of the upper portions of the orebody, waste rock, and tailings piles with off-site disposal in a lined facility; removal of contaminated sediments in the affected tributaries and the Spring Creek Reservoir; and the removal of the Minnesota Flats tailings pile.	1,400	0.0[3]	Achieves background water quality at all points.

Table 12 (Continued)

ALTERNATIVE	COST ($ Million)		ANTICIPATED BENEFIT
	Capital	O&M (Present Worth)	EPA Water Quality Criteria (EPAWQC) State Basin Plan Objectives (SBPO)
CA-11 Removal of the Minnesota Flats tailings pile and sediments in the tributaries and Spring Creek Reservoir with off-site disposal; collection of leachate from all point and non-point sources, and treatment of the collected leachate with lime neutralization. This alternative includes construction of a nearby RCRA-type sludge disposal facility.		351[4]	Achieves background water quality at all points below the leachate collection impoundments near the confluence of Spring Creek and Flat Creek and Spring Creek and Slickrock Creek. Flat Creek and Slickrock Creek will remain contaminated upstream of these impoundments.
CA-12 Utilization of the Spring Creek Reservoir as a collection basin for all point and non-point leachate sources and treatment of all liquids passing through the reservoir with lime neutralization.		263[4]	Achieves background water quality at all points below Spring Creek Reservoir. The reservoir and upstream tributaries will remain contaminated.

Notes:

1. Since CA-1 did not meet water quality objectives, costs were not computed further, and CA-1 was effectively screened out.

2. Costs computed for achieving EPAWQC below Keswick Dam for water year 1978.

3. Costs for CA-10 through CA-12 not computed to same level of detail as for CA-2 through CA-9.

4. These costs include both capital and O&M costs.

5. Technical, environmental, public health and institutional considerations can be found in Table 11 for the components which make up the combined alternatives.

VII. THE IRON MOUNTAIN MINE REMEDY

Among the remedial action alternatives that could be implemented by EPA, the total removal of the source and sediments in receiving waters (Alternative CA-10) is considered the only remedy for the Iron Mountain Mine site which is capable of meeting project cleanup objectives and the full requirements of the Clean Water Act (CWA). This alternative would effectively eliminate discharges from Iron Mountain and restore all tributaries to pristine condition. This alternative was based on total removal of all the sources of contamination and hauling and disposing of them in a RCRA-approved facility. This includes material from the following four areas:

a) Remove approximately 3.5 million cubic yards of ore and waste rock and tailings piles along Boulder Creek and Slickrock Creek.

b) Remove an estimated 200,000 cubic yards of contaminated bottom sediments in Slickrock Creek, Boulder Creek and Spring Creek. It was assumed that sediment in Slickrock Creek near the Brick Flat Pit area would be removed using conventional construction equipment. For sediment removal in the other receiving waters, hydraulic clearing was assumed.

c) Remove approximately 620,000 cubic yards of contaminated bottom sediments in Spring Creek Reservoir.

d) Remove about 14,000 cubic yards of tailings material in the Minnesota Flat area.

The total cost of excavating and removing the source material and hauling it to a Class I landfill was estimated to be $1.4 billion.

Alternative CA-11 comes next closest to meeting all requirements, but water quality standards will not be met in Boulder Creek and Slickrock Creek and not all non-point sources will be addressed through Best Management Practices (BMP's). This alternative is the same as the total removal alternative except it does not include removing the orebody. It only includes removing bottom sediments in the creeks and reservoir and the Minnesota Flat Tailings pile. All costs developed for this portion of this alternative are based on the same assumptions discussed in CA-10. This would consist of excavating and removing over 800,000 cubic yards of waste to a RCRA approved landfill which is estimated to cost about $200 million.

This alternative will collect all point and non-point sources in Slickrock Creek and Boulder Creek; the contaminated water would be conveyed to a lime neutralization facility for treatment. This alternative would also include constructing a nearby sludge disposal site which would meet RCRA guidelines and all other institutional requirements. The estimated cost of treatment is $151 million, bringing the total cost of the alternative to $351 million.

Alternative CA-12 will meet background water quality in the Sacramento River below Keswick Dam but the applicable federal and state standards will not be met in Boulder Creek, Slickrock Creek, portions of Spring Creek, and in the Spring Creek Reservoir. This alternative involves allowing all point and non-point sources of pollution to discharge to Boulder Creek and Slickrock Creek, and then flow into the Spring Creek Reservoir. Contaminated water would then be pumped to a lime neutralization facility for treatment; treated water would be discharged to the Sacramento River. The resulting lime sludge would be disposed of in a nearby disposal site which would meet RCRA guidelines and other institutional requirements. Water quality standards should be met in Flat Creek since the only source of pollution, Minnesota Flats Tailings pile will be removed under this alternative. Also, non-point sources will not be treated with BMP's.

Under CA-1, water quality standards would not be met in either the immediate receiving waters or in the Sacramento River below Keswick Dam for several of the case years evaluated. CA-2 through CA-9 would improve water quality to varying degrees in immediate receiving waters, although not to the point where state water quality standards will be met; these objectives will, however, be met in the Sacramento River below Keswick Dam. With the exception of CA-9, these alternatives will not address discharges from non-point sources.

VIII. FUND BALANCING

Under 40 CFR §300.68(i)(1), the appropriate extent of remedy must be the cost-effective remedial alternative that effectively mitigates and minimizes threats to and provides adequate protection of public health and welfare and the environment. In addition, the remedy must be that which attains or exceeds applicable or relevant and apropriate Federal public health and environmental requirements that have been identified for the site. However, under §300.68(i)(5)(ii), EPA may select an alternative that does not meet applicable or relevant and appropriate Federal public health or environmental requirements when the need for protection of public health and welfare and the environment at the facility for all of the alternatives that attain or exceed applicable or relevant and appropriate Federal requirements is outweighted by the need for action at other sites that may present a threat to public health or welfare or the environment, considering the amount of money available in the Hazardous Substance Response Trust Fund. In the event of Fund-balancing, EPA must select the alternative which most closely approaches the level of protection provided by applicable or relevant and appropriate Federal requirements, considering the specific Fund-balanced sum of money available for the facility.

The estimated cost to implement the remedy (CA-10) that would meet applicable or relevant and appropriate Federal environmental and public health standards for the Iron Mountain Mine site is estimated to be $1.4 billion. EPA evaluated the funds remaining under the current Superfund authorization and subsequent interim fundings. In our analysis, we have considered that increased funding may become available if the pending Superfund reauthorization is enacted.

At this time, funds under the current Superfund authorization and the subsequent interim funding are nearly depleted; funding that remains is committed solely to keep ongoing remedial planning activities on an active status. Therefore, these remaining funds are not only unavailable to Iron Mountain Mine but, even if available, would not be adequate to implement an operable unit or final remedy at the site.

The Superfund reauthorization, if enacted, may provide funding in an amount ranging from $5.4 billion to about $8.5 billion in order to respond to 888 proposed and final NPL sites over a five year period ($1.7 billion annually). Committing $1.4 billion, or 16 to 26 percent of the potentially reauthorized amount, to the cleanup of Iron Mountain Mine would effectively consume at least the equivalent of one year's worth of funding. This would be at the expense of remedial response action at NPL sites, expenditures for emergency response action, and other program needs. This would severely limit the capability of the Agency to take timely and effective cleanup action where needed to protect public health and welfare and the environment. The full impact of commiting these funds solely to Iron Mountain Mine would be to deny funding for site cleanup at between 140 and 470 NPL sites (assuming that the typical cost of Remedial Design and Remedial Action for an NPL site ranges from $3 million - $10 million).

As previously mentioned, Alternative CA-11 at a cost of $351 million is the alternative that most closely approaches but does not achieve the requirements of the CWA. This alternative would utilize Boulder Creek and Slickrock Creek to capture all point and non-point sources of pollution; contaminated water would then be pumped from each of the two creeks to a lime neutralization facility for treatment. Alternative CA-11 is expected to further degrade water quality beyond current conditions in these receiving waters. The reason is that, at present, discharges of AMD from the three major sources of pollution are receiving copper cementation treatment prior to discharge to receiving waters. Nevertheless, water quality in Spring Creek, Spring Creek Reservoir, and Keswick Reservoir would improve substantially to the point where certain beneficial uses may return on a year round and/or seasonal basis. Water quality below Keswick Dam would improve beyond that required to protect fish in the Sacramento River. Committing funds for this alternative would be at the expense of funding cleanup actions at between 35 and 117 NPL sites.

Alternative CA-12 would further degrade water quality in Boulder Creek, Slickrock Creek, portions of Spring Creek and in Spring Creek Reservoir because AMD from the three major sources of pollution will not receive copper cementation treatment prior to discharge to receiving waters. Contaminated water would be pumped from Spring Creek Reservoir to a lime neutralization facility for treatment and then discharged to the Sacramento River. However, water quality in Keswick Reservoir and below Keswick Dam would improve substantially; water quality below Keswick Dam would be essentially the same as that in the Sacramento River above the confluence where discharges from Iron Mountain Mine enter the river. The level of cleanup provided by this alternative is higher than that needed to protect aquatic life in the Sacramento River below Keswick Dam. Funding this alternative would preclude EPA from taking cleanup action at between 26 and 87 sites on the NPL.

After considering these fund-balancing issues, CA-9 ($72.2 million) is the alternative that most closely approaches the requirements of all applicable or relevant and appropriate federal and state requirements, yet it also balances the need to conserve monies in the Fund. Funding this remedy would have a less significant impact on EPA's ability to use the fund at other sites, yet it would also provide significant protection at the IMM site. Alternative CA-9 will meet Federal Water Quality Standards for aquatic life below Keswick Dam for all water years considered; the State Basin Plan standards should be met for other than the 'worst case' condition. Meeting these criteria and standards should protect the salmon population in the Sacramento River below Keswick Dam. In addition, implementation of Alternative CA-9 should greatly improve water quality in the tributary streams between Iron Mountain and the Sacramento River. The basis for identifying CA-9 as the Fund-balanced remedy is discussed in more detail in Chapter IX.

IX. SUMMARY EVALUATION OF ALTERNATIVES

With the exception of CA-1, each combined alternative will meet the two project cleanup objectives for each of the case years for which they were analyzed. Alternative CA-1 will not meet EPA standards for 1978 and 1981 conditions or State Basin Plan objectives for the years 1978, 1981, and 1983.

A. Features and Costs of Combined Remedial Alternatives

Alternative CA-1 does not meet either EPA or State water quality objectives and is not considered an appropriate remedial action alternative for site cleanup because releases from the site would continue to present acute and chronic impacts on aquatic life.

Alternatives CA-2, CA-3, and CA-4 will meet both EPA and State water quality objectives through various combinations of source control, lime/limestone neutralization treatment, and water management alternatives at costs ranging from $89.6 million to $151.1 million. These alternatives differ in the number of AMD sources that will receive treatment.

Alternatives CA-5, CA-6 and CA-7 will also meet both project cleanup objectives at a cost substantially below those projected for Alternatives CA-2 through CA-4. These alternatives differ most notably in the increased storage capacity of the Spring Creek Reservoir provided by the enlargement of Spring Creek Debris Dam. Alternative CA-5 will meet cleanup objectives by relying exclusively on water management measures to ensure that adequate dilution water is available to meet project cleanup objectives below Keswick Dam. Under this alternative, no source control or treatment remedies would be implemented. Alternative CA-6 is similar to Alternative CA-5 except that this alternative would utilize copper cementation treatment of 'controlled' AMD flows at a lower cost to meet EPA cleanup objectives and slightly higher cost to meet State cleanup objectives. Alternative CA-7 relies upon source control, treatment, and water management remedies to meet EPA and State cleanup objectives at a higher cost than both Alternatives CA-5 and CA-6 but considerably lower than Alternatives CA-2 through CA-4.

Alternatives CA-8 and CA-9 meet project cleanup objectives through a variety of source control, treatment, and water management remedies. These alternatives are very similar and differ only in the extent of capping that would be required over the Richmond orebody, and the volume of AMD receiving lime/limestone neutralization treatment. CA-9 also includes the injection of low-density cellular concrete; this is not a component remedy of CA-8. CA-8 will meet federal and state objectives at costs ranging from $55.3 million - $62.7 million; CA-9 will meet the same objectives at a cost of $72.1 million to $85.1 million. Although the cost of CA-9 may be higher, the actual cost of CA-9 may be less for several reasons: a) further studies may indicate that the underground mine workings do not need to be completely filled with LDCC; 2) if waste rock at Big Seep can be used in the formation of LDCC, the Upper Slickrock Creek diversion ($790,000) could possibly be eliminated; and 3) if LDCC is fully successful, it would preclude the need to construct a lime neutralization facility, which has an estimated capital cost of about $8 million. More important, however, CA-9 is an approach that aggresively moves to stop AMD formation. Under other alternatives, for instance, AMD may continue to be formed, and thus require treatment, for hundreds of years.

B. Evaluation of Combined Remedial Alternatives

CA-2 through CA-4 will meet primary and secondary cleanup objectives and the goals of the NCP at a relatively high cost when compared to the other alternatives. CA-2 and CA-3 treat the five major sources of pollution plus all other sources discharging in Slickrock Creek through lime neutralization; CA-4 addresses these same sources in addition to treating all other sources in Boulder Creek. These alternatives will be generating tremendous volumes of lime sludge each year which, on a periodic basis will continue to require the identification and development of new off-site disposal areas. Treatment of AMD and off-site disposal will be required for a period of time far exceeding the 30-year project period, and perhaps be needed in perpetuity. This, in effect, significantly increases the State's commitment to operate and maintain the lime neutralization facilities, and will require that nearby undeveloped land be committed for land disposal for as long as Iron Mountain Mine continues to discharge AMD. The need for long-term treatment tends to make these alternatives less reliable. These alternatives would reduce the metals loading to receiving waters and meet Federal and State standards, but for the added cost, would not result in a further improvement in Water Quality at the point of compliance. For the above reasons, CA-2 through CA-4 are not considered cost-effective remedies for the Iron Mountain Mine problem.

CA-5 will meet both EPA and State water quality objectives at the point of compliance (primary objective) at a relatively low cost, but will not meet a principal goal of the NCP or the secondary cleanup objective. The reason for this is that CA-5 does not address the problem at its source or minimize the migration of hazardous substances, pollutants or contaminants because it relies exclusively upon the dilution of these pollutants to meet primary cleanup objectives. For these reasons, this alternative was not considered to be an appropriate remedy for Iron Mountain Mine.

CA-6 utilizes copper cementation treatment, and like CA-5, relies on dilution to meet primary cleanup objectives. For the same reasons as discussed under CA-5, and in consideration of the fact that copper cementation will not meet the BAT requirements of the CWA, this alternative was not considered an appropriate CERCLA response to the Iron Mountain Mine problem.

When compared to CA-5 and CA-6, alternative CA-7 provides an improved balance of source control, treatment and water management components to meet primary and secondary cleanup objectives at a slightly higher cost. CA-7 also utilizes copper cementation treatment and, thus, will not meet Best Available Technology, as specified by the CWA. CA-7 will result in a reduction of pounds per day of heavy metals entering the Sacramento River through implementation of source control and treatment alternatives, but to a lesser extent when compared to other source control and lime neutralization treatment alternatives. This is because the copper cementation process does not remove cadmium or zinc from the AMD. Therefore, while CA-7 will meet the primary cleanup objective, it will only partially fulfill the secondary objective. Also, CA-7 will do very little to improve overall water quality in immediate receiving waters. For these reasons, CA-7 was not considered an appropriate remedy for Iron Mountain Mine.

CA-8 and CA-9 are very similar as previously noted and will, therefore, be evaluated together. Both of these alternatives provide a good balance of source control, treatment and water management. By utilizing lime neutralization treatment of the three major sources, both CA-8 and CA-9 will satisfy the BAT requirement of the CWA. This, combined with capping (and in the case of CA-9 the use of LDCC) will result in substantial water quality improvement in the immediate receiving waters and will, therefore, reduce the amount of heavy metals discharged to the Sacramento River. For approximately 6-8 months of the year, from about late-Spring to early-Fall, there should be no discharges of AMD to receiving waters. During these periods, it is anticipated that there will be a return of certain beneficial uses to Keswick Reservoir and possibly a return of other beneficial uses to portions of Spring Creek.

In the case of CA-9, lime neutralization treatment may not be needed if the injection of LDCC is successful in preventing or reducing the formation of AMD. Even if LDCC is not fully successful, the volume of AMD that would need to be treated is thought to be much less than under CA-8. Therefore, Brick Flat Pit will have a sustained storage life for lime sludge beyond the 30-year period calculated for CA-8. This means that off-site disposal can be postponed to a later date and the rate of developing new off-site disposal sites under CA-9 will be slower when compared to CA-8. CA-9 will also utilize waste rock and tailings piles and treated AMD from the three major sources when formulating the LDCC. This brings CA-9 an additional step forward in meeting the requirement of the CWA by addressing non-point sources; these sources will not be addressed by CA-1 through CA-8.

The most attactive feature of CA-9, however, is the use of LDCC. If fully successful, this alternative could prevent or significantly reduce AMD to a point where treatment may not be required. This, of course, would mean that there would no longer be a need to utilize Brick Flat Pit as a storage basin or a need to identify and develop new off-site lime sludge disposal sites. It is this aspect of CA-9 that makes it a superior choice over the other combined remedial action alternatives.

X. IDENTIFICATION OF FUND-BALANCED REMEDY AND REMEDY SELECTION STRATEGY

Alternative CA-9 is the appropriate Fund-balanced remedy for Iron Mountain Mine. Alternative CA-8 is EPA's next preferred alternative. These two alternatives differ principally in the use of LDCC, in the volume of AMD to receive lime/limestone neutralization treatment, and whether a partial cap (CA-9) or complete cap (CA-8) is constructed.*

Full implementation of alternative CA-9 is expected to significantly improve water quality in the Iron Mountain Mine area. Table 13 presents the anticipated water quality benefits that should result from CA-9. Water quality in Keswick Reservior and the Sacramento River would also see similar water quality improvements. Removing the Minnesota Flats Tailings pile, the only known source to impact Flat Creek, would result in immediate improvements in water quality and, over time, may cause a return of all beneficial uses to this water course.

Reducing the metals loading to receiving waters would also mean that there are fewer heavy metals in solution; fish in the Sacramento River have been shown to bioaccumulate these metals. If it were possible that bioaccumulation, which has been demonstrated in fish tissue, was also causing a potential human health problem, we anticipate that this impact would be eliminated or reduced by the remedial action program.

Also, installation of perimeter control (i.e., fencing, posting warning signs) should minimize potential public health impacts associated with coming into contact with AMD or AMD-laden waters.

The selected alternative for this operable unit consists of the source control and water management components that are common to both CA-8 and CA-9. The Agency is not now prepared to make a final decision on whether to proceed with the source control measure of injecting low-density cellular concrete into the underground mine workings or straight lime/limestone neutralization treatment of AMD. To assist in making this decision,

Table 13. Anticipated Water Quality Improvements with CA-9

	Current Water Quality (mg/l)				CA-9			
RECEIVING WATER	COPPER	ZINC	CADMIUM	pH	COPPER	ZINC	CADMIUM	pH
BOULDER CREEK	4.25	25.0	0.17	2.1-3.3	1.20	6.1	0.03	2.7-4.0
SLICKROCK CREEK	2.56	0.99	0.012	3.5-4.1	0.15	0.06	0.001	4.7-5.5
SPRING CREEK	1.2	4.7	0.03	3.0-3.4	0.47	2.1	0.01	3.4-4.5

this ROD authorizes EPA to conduct a hydrogeologic investigation, and LDCC pilot and demonstration testing to determine a) if the site is conducive to the application of LDCC; b) the proper formulation of LDCC needed to withstand AMD corrosion; and c) if LDCC is technically feasible, reliable, and can be successfully implemented at Iron Mountain Mine. If these studies conclude that LDCC is technically feasible and can be implemented, EPA will prepare a second Record of Decision (ROD) documenting the selection of the source control measure.

Alternatively, if the site is not conducive to the application of LDCC or if LDCC is judged to be technically infeasible, a second ROD will be prepared to select the components of CA-8 (complete capping of the Richmond orebody and lime/limestone treatment) that have not been selected by this ROD.

* Construction of a partial or complete cap over the Richmond ore body is consistent with EPA's current view of Iron Mountain as a waste source. A cap will reduce infiltration of precipitation and thus reduce the volume of acid mine drainage that is formed. However, the ore body could be considered a resource, suitable for exploitation by a solution mining process (as currently proposed by the potentially responsible parties). Placing a full or partial cap over the ore body could be a hindrance to efforts to implement a solution mining process. Therefore, EPA will not begin implementation of the capping component for a grace period, while the possibility of developing the ore body as a resource is considered further. Commercial development of the ore body would have to include acid mine drainage discharge control measures and other environmental safeguards. A final decision regarding the capping component will be made following the grace period.

XI. SUMMARY OF RECOMMENDED OPERABLE UNIT

The recommended operable unit consists of:

o Approximately 2.5 acres of cracked and caved ground areas above the Richmond orebody will be capped using a soil cement mixture or other suitable material. The areas will be graded and benched and covered with the soil cement mixture. Interception ditches will be used to divert clean surface water runoff from the orebody.

o Up to 800 cubic feet per second (cfs) of clean surface water will be diverted from the Upper Spring Creek watershed before it reaches that portion of the basin affected by Iron Mountain Mine. This will be accomplished by constructing a low diversion dam and an 8-foot tunnel .

through the ridge that separates the Spring Creek and Flat Creek watersheds. A chute and energy dissipators will be needed to complete the conveyance of flows from Spring Creek to Flat Creek.

o Up to 250 cfs of clean water will be diverted from the South Fork of Spring Creek across the drainage divide into Rock Creek which discharges to the Sacramento River below Keswick Dam. The purpose of this alternative is similar to the Upper Spring Creek diversion and will require a small diversion dam and 4,000 feet of pipeline to complete the conveyance of flows to Rock Creek.

o Clean water from Upper Slickrock Creek will be diverted around the waste rock and slide debris, which contribute to releases from Big Seep, to the lower reach of Slickrock Creek.

o Spring Creek Debris Dam will be enlarged from its present storage capacity of 5,800 acre feet to 9,000 acre feet.

o Installation of Perimeter controls as necessary to minimize any direct contact threats.

o Perform hydrogeologic study and field-scale pilot demonstration to better define the feasibility of utilizing LDCC to minimize AMD formation.

XII. RECOMMENDED CLEANUP OBJECTIVES AND DESIGN YEAR

Designing a cleanup program to meet EPA Water Quality Criteria for Protection of Aquatic Life for the 'worst case' condition (1978) was judged to be appropriate because it is under conditions similar to 1978 that the greatest impacts on aquatic life would be felt. It should be noted that the so-called "worst case" year is based on very few years of data. Also, water quality model runs predicted that, targeting a cleanup program to meet EPA water quality criteria for the 1978 runoff conditions (wet year following a drought) would ensure that more stringent State criteria for the other three cleanup case years would be met. Stated differently, the EPA program should meet State criteria for every year except the worst case year, at which time the federal standards will be met. Under these conditions, meeting federal standards should prevent fish kills from occurring in the Sacramento River.

XIII. CONSISTENCY WITH OTHER ENVIRONMENTAL LAWS

According to the NCP, 40 CFR Part 300.68 (i)(1), remedial actions must attain or exceed applicable or relevant and appropriate Federal public health and environmental requirements unless one of the exceptions of Section 300.68(i)(5) applies. One of these exceptions is Fund-balancing. This provision allows EPA to select the alternative which most closely approaches the level of protection provided by applicable or relevant and appropriate requirements by considering the amount of money remaining in the Trust Fund and the need to take action at other NPL sites.

The selected overall remedy (CA-9) is presented for the discussion of the consistency with other environmental laws even though the current ROD is for the first operable unit only. The selected remedy would fill the major mine workings with low-density cellular concrete to greatly reduce AMD production; partially cap Iron Mountain to reduce the infiltration of clean water into the ore body; divert clean surface waters away from tailings piles and contaminated areas; if necessary, treat the (reduced) flow of AMD from the major point sources by lime neutralization; and enlarge Spring Creek Debris Dam to provide flow equalization. In order to reduce infiltration of clean water into the mountain, some grading and filling of depressions is anticipated in addition to the partial cap. In particular, an open pit called the Brick Flat Pit is to be filled to prevent accumulation of water. Dewatered sludges from the lime neutralization process, as well as the tailings from the Minnesota Flats Tailings piles, will be placed in the Brick Flat Pit. The selected remedy does not: address all waste rock dumps or tailings piles along Boulder Creek and Slickrock Creek; collect and treat all seeps or subsurface drainage along Boulder Creek and Slickrock Creek; address metal-bearing sediments in receiving waters; or fully achieve aquatic water quality standards in Boulder Creek, Slickrock Creek, portions of Spring Creek, and Keswick Reservior. In essence, the selected remedy will achieve aquatic water quality standards below Keswick Dam, but not in the tributary streams; however, water quality in these receiving waters is expected to improve substantially to the point where certain beneficial uses may return on a seasonal basis.

The major environmental statutes that should be addressed with regard to this site include the Resource Conservation and Recovery Act (RCRA), the Clean Water Act (CWA), the National Environmental Protection Act (NEPA), and the Endangered Species Act (ESA). In addition, the selected alternative's consistency with a number of other Federal and State regulations is discussed in the Feasibility Study and its Addendum.

<u>RCRA</u>

The partial capping of the mountain and the filling of Brick Flat Pit with tailings from the Minnesota Flats area as well as disposing of dewatered lime sludges are two components of the selected remedial action that are of interest here. Iron Mountain Mine is an inactive mining site, and the solid materials found at the site are considered mining wastes; hence, RCRA is not generally applicable or relevant or appropriate. However, portions of the RCRA Subtitle C requirement may be relevant and appropriate for some aspects of the remedy. We considered the RCRA Subtitle C requirements in formulating various aspects of the alternative remedial actions. In addition, Subtitle D requirements may be appropriate at the site. In particular, grading and capping to reduce infiltration of rain waters into tailings piles (or the ore body) seems appropriate. The partial cap is intended to be placed over badly fractured areas and areas of relatively low slope. A soil/cement mixture appears to be the most cost-effective approach to reducing infiltration into the ore body: The multi-layered clay cap does not appear to be necessary for this application. Also, because of the steepness of some of the slopes, complete capping of the mountain is not technically feasible or practical.

With regard to the disposal of sludges generated by the lime neutralization process, it may be most protective to place the sludges (after dewatering) in a double-lined facility. Such a facility would have to be located off-site, because there are no areas suitable for such a facility on-site. However, the selected remedy is to place these sludges in Brick Flat Pit on top of Iron Mountain. This is considered a more appropriate approach for several reasons: (1) the pit needs to be filled in order to prevent water from ponding in it, (2) the metals contained in the dewatered sludge are relatively immobile and hence should be safe to place in an unlined pit, (3) should the metals migrate, they would reenter the ore body and eventually be recaptured by the AMD treatment system, and (4) the pit provides the probable least-cost disposal option. It is estimated that Brick Flat Pit could provide 30-plus years of disposal capacity, depending on sludge generation rates. (If the LDCC is fully successful in stopping AMD formation, then no treatment would be required, and no sludges would be generated.)

Placement of the tailings from the Minnesota Flats area in Brick Flat Pit is also selected. The tailings came from an ore roasting operation near Iron Mountain, and they contribute approximately one percent of the total metals discharge from the site via surface water runoff. Removal of the tailings from their present location would allow Flat Creek to be restored. Placement of these materials in Brick Flat Pit is somewhat analogous to placing materials that have migrated off-site from a landfill back on the landfill prior to capping. The metals concentrations are less that those of the underlying ore body, and the volume is significantly less than that of the ore body.

<u>CWA</u>

Section 301 of the Federal Clean Water Act requires that any point source discharge to waters of the United States meet technology-based effluent limitations (Best Practicable Technology Currently Available (BPT) by July 1, 1977, and Best Available Technology Economically Achievable (BAT) by July 1, 1984) as well as effluent limitations necessary for achieving compliance with water quality standards, by July 1, 1977. All Clean Water Act requirements may be met by preventing discharge. Waters of the United States in the Iron Mountain Mine area include Boulder Creek, Flat Creek, Slickrock Creek, Spring Creek, Keswick Reservoir, and the Sacramento River.

EPA has determined by Best Professional Judgement that the effluent limitations for mine drainage at 40 CFR Part 400, Subpart J, which are achievable by using lime treatment and precipitation, meet the BPT/BAT/BCT requirements of the CWA for point source discharges at this site.

Water quality standards established pursuant to the CWA are currently applicable to the Sacramento River and tributaries above Hamilton City. These standards were adopted by the Central Valley Regional Water Quality Control Board on April 27, 1984, and were approved by the State Water Resources Control Board and EPA. These standards limit dissolved concentrations of cadmium (0.00022 mg/l), copper (0.0056 mg/l), and zinc (0.016 mg/l). Other applicable water quality standards include a pH range of 6.5 to 8.3, with a maximum deviation of 0.3 units from ambient conditions, as well as freedom from color, turbidity, settleable material, sediment, toxicity, and suspended materials in amounts that adversely affect beneficial uses. Water quality standards are currently violated at all times for each of these water bodies except for the Sacramento River below Keswick Dam.

While substantial water quality improvement above current conditions is expected through implementation of Alternative CA-9, State and Federal standards will probably not be met in portions of Spring Creek, Slickrock Creek, Boulder Creek, and Keswick Reservoir at any time. Alternative CA-9 achieves water quality at a point below Keswick Dam. As described under Fund Balancing, the cost of meeting water quality objectives in the stream near the source is extremely large and fund balancing is used to back off to a less costly remedy.

NEPA

Under NEPA, an Environmental Impact Statement (EIS) must be prepared for Federally-funded projects. The environmental analysis included in the Feasibility Study is normally considered to be the functional equivalent of the EIS. However, in this case, the environmental impact of the proposed stream diversions are beyond the scope of the Feasibility Study. Therefore, prior to final design and construction of water diversion components or changes in the crest or pool elevations of the Spring Creek Debris Dam, the Bureau of Reclamation, under an agreement with EPA, will conduct any necessary supplemental environmental assessments.

ENDANGERED SPECIES ACT OF 1973

The winter run of salmon are being considered by the National Marine Fisheries Service for protection under the Endangered Species Act. Therefore, if the Service takes final action to protect the winter run of salmon, this legislation would be applicable to the cleanup of Iron Mountain Mine since the site is the main source of pollution that places the salmon at risk. The operable unit and final remedy for Iron Mountain Mine will achieve water quality standards in the Sacramento River below Keswick Dam, the major spawning area for the salmon. In taking remedial action at Iron Mountain Mine, EPA will be in compliance with the intent of the Endangered Species Act.

XIV. OPERATION AND MAINTENANCE

A. Capping of Cracked and Caved Ground Areas

Maintenance will be required for the ditches, benches, and soil-cement cap. The ditches will require periodic maintenance consisting of the removal of debris and repair of cracked sections. Benches will need periodic removal of debris.

B. Water Management Alternatives

Expected operation and maintenance requirements are minimal for these alternatives. There are no mechanical or electrical system components to maintain and no process to monitor or manage. It is possible after an extreme runoff event that some repair of channel erosion damage could be required. Sediment accumulation could be a problem at some point in the system, although proper design considerations should reduce any associated maintenance problems to a minimum.

XV. COMMUNITY RELATIONS

Documents made available for public review and comment included the Remedial Investigation (RI) and Feasibility Study (FS) reports and the Addendum to the FS.

The RI was made available for review and comment in February 1985, and again on August 2 through August 23, 1985. The public comment period for the FS was held between August 2 and August 23, 1985. Public notification of the public comment period was announced two weeks prior to the public comment period through notices in local newspapers. A Fact Sheet summarizing the contents of the RI and FS reports was sent to the mailing list during the week of July 22, 1985. A public meeting was held on August 15, 1985 in Redding, CA. The majority of comments received at the public meeting were from IMMI and Stauffer. These parties stated their objections to the implementation of the EPA cleanup program, and voiced strong support for allowing IMMI to proceed with its concept for an in situ leaching and metals recovery project.

Written comments were received from the PRP's, state agencies, one resident along Flat Creek, and sportsfishing and recreational organizations. In general, the PRP's and their consultants supported the IMMI proposal, stated opposition to an EPA funded cleanup action, and called into question the credibility of the FS. State agencies and other organizations lent support for an EPA funded remedial action and raised concerns about proceeding with the IMMI proposal. Responses to the comments are presented in the attached Responsiveness Summary.

A fact sheet summarizing the results of the Addendum to the FS was sent to the mailing list on July 14, 1986. The public comment period for the Addendum was held from July 25 through August 15, 1986. Public notification of the public comment period was announced about three weeks prior to the public comment period through notices in local newspapers.

Written comments were received by the PRP's, federal and State regulatory agencies, two landowners near the site, consultants associated with IMMI, and 33 citizens who signed petitions and/or form letters supporting the IMMI proposal, and 5 letters from residents in the Redding area.

As a general statement, comments from the PRP's and consultants for IMMI stated firm support for the IMMI proposal and opposition to the EPA proposed cleanup program. There was a concern that injecting the LDCC into the underground mine workings would interfere with the IMMI proposal and would also destroy a valuable mineral resource. The PRP's voiced strong opposition to proceeding with LDCC because it is an unproven technology for the purposes for which it would be applied at Iron Mountain Mine. The PRP's stated that the technology was not technically feasible; Stauffer indicated that, for this reason, the approach was not consistent with the NCP because it was not an established technology. The PRP's also stated that the IMMI proposal was a far superior alternative and that IMMI had secured funding to finance its commercial mining venture and an environmental control program. Stauffer asserted its view that Region IX had incorrectly interpreted the Clean Water Act in applying BAT for control of AMD from "abandoned mines"; that water quality compliance criteria must be negotiated on a case-by-case basis, and that the point of compliance for meeting cleanup objectives should continue to be met below Keswick Dam. Stauffer also protested that the three week public review and comment period was inadequate and inconsistent with CERCLA and the community relations provisions of the NCP because the Addendum represented a sharp departure from the original FS and that important and complex technical issues were raised by the FS Addendum.

The petition and form letters stated that the IMMI proposal was needed to bolster Shasta County's economy, that the IMMI cleanup program was more efficient and cost effective than the EPA cleanup programs, that the impacts of discharges of AMD on the Sacramento River are highly questionable, and that the EPA cleanup program was "basically ludicrous".

Federal and state regulatory agencies agreed with the implementation of CA-9 as the best solution to the Iron Mountain Mine problem, although support was also mentioned for CA-8; there was a consensus of the regulatory agencies opposing the IMMI commercial mining venture as an acceptale response to site problems. Specific comments and EPA's responses are presented in the attached Responsiveness Summary.

XVI. SCHEDULE

o Approve Remedial Action: Sign Record of Decision	Week of September 22, 1986
o Commence Remedial Design and Remedial Action of Water Management alternatives	Funding Pending Reauthorization of CERLCA

Once CERCLA has been reauthorized, the RD/RA phase for Iron Mountain Mine is proposed to be implemented in the following manner:

1.	Pre-Design for all source control and treatment components	FY 1987, 1st QTR
2.	Hydrogeologic investigation and LDCC pilot and demonstration test	FY 1987, 1st QTR
3.	Remedial Design	FY 1987, 3rd QTR
	a) Partial capping	
	b) Upper Slickrock Creek diversion	
	c) South Fort Spring Creek diversion; and	
	d) Upper Spring Creek diversion	
4.	Remedial Action	
	a) Partial capping	FY 1987, 4th QTR
	b) Upper Slickrock Creek diversion	FY 1988, 1st QTR
	c) South Fort Spring Creek diversion; and	FY 1988, 3rd QTR
	d) Upper Spring Creek diversion	FY 1988, 3rd QTR
5.	Remedial Design: LDCC (if feasible)	
	a) Richmond	FY 1989, 3rd QTR
	b) Slimrock	FY 1990, 2nd QTR
6.	Remedial Action: LDCC	
	a) Richmond	FY 1991, 1st QTR
	b) Slimrock	FY 1991, 3rd QTR
7.	RD/RA: Lime Neutralization (if needed)	Will be determined by results of LDCC pilot and demonstration tests.

XVII. FUTURE ACTIONS

After this Record of Decision is signed, EPA will enter into an Interagency Agreement with the U.S. Bureau of Reclamation (Bureau) for the design and construction of the source control and treatment components of the selected remedial action. In this manner, the Bureau will function in a role identical to that of the U.S. Corps of Engineers under the Superfund program and will oversee and manage the design and construction of the selected remedial action. This agreement will build upon the national interagency agreement between EPA and the Bureau for the cleanup of NPL sites.

The Bureau will assist EPA's cleanup efforts by seeking funding for the design and construction of the water management components of the selected remedial action. EPA may need to advance Trust Fund monies to the Bureau to begin certain of these activities so as to not interupt the site cleanup process. Under the terms of the agreement, the Bureau will reimburse EPA for these advanced monies.

Implementation of the selected alternative is expected to proceed under a phased approach, with monitoring following the construction of each component remedial action alternative. This will allow EPA to fully determine the efectiveness of each alternative. The phased approach will be implemented in the following manner:

<u>OPERABLE UNIT</u>

- <u>Capping above Richmond orebody</u>

  Design - 6 months

  Construction - 9 months (under suitable weather conditions)

- <u>Surface Water Diversions</u>

  Design - 12 months

  Construction - 18 months

- <u>Enlargement of Spring Creek Debris Dam</u>

  Design - 18 months

  Construction 18 months

  (This component will not begin RD/RA until all the source control, treatment (if needed) and water management components have been constructed and monitored for their effectiveness).

- Richmond Hydrogeologic Investigation

  The object of the investigation is to:

  1. Identify the main sources of inflow and AMD to the underground mine workings;

  2. Determine the vertical and lateral distribution of hydraulic head and permeability; and

  3. Evaluate slope stability and the strength of geologic material.

  These objectives will be accomplished, in part, through a groundwater drilling program and an assessment and survey of the underground mine workings. This investigation may identify another fill material or source control measures that may be equally or better suited for the Iron Mountain Mine site. Should this be the case, Region IX would propose to expand the LDCC pilot test described below to include an examination of these alternatives.

- Pilot and Demonstration Test of Low-Density Cellular Concrete

  1. Pilot Test

  The objective of this test is to determine the proper formulation of LDCC to withstand attack and corrosion from AMD. This will include a) laboratory test that will examine the effects of acid attack on various cement and additives; b) adhesion and fracture and interface leach tests to determine the applicability of LDCC to an acid environment; and c) determination of the geotechnical and hydrologic characteristics of LDCC.

  2. Demonstration Tests

  A small-scale demonstration test, and possibly a larger-scale test, will be conducted in the underground mine workings; this will require the partial rehabilitation of the Richmond adit. If a larger-scale test is deemed necessary, it will, in all likelihood, be conducted in the Lawson portal; in effect, this test will serve as the first phase of the implementation of LDCC.

  The final scope and cost of the ground water investigation and the LDCC pilot and demonstration test are currently in the process of being fully developed.

- Implement perimeter control as needed to minimize direct contact threat.

STATE OF CALIFORNIA—HEALTH AND WELFARE AGENCY Attachment 2 GEORGE DEUKMEJIAN, Governor

DEPARTMENT OF HEALTH SERVICES
TOXIC SUBSTANCES CONTROL DIVISION
NORTHERN CALIFORNIA SECTION
4250 POWER INN ROAD
SACRAMENTO, CA 95826
(916) 739-3145

September 11, 1986

Mr. Keith Takata, Chief
Superfund Program Branch
Toxics and Waste Management Division
U.S. Environmental Protection Agency
Region IX
215 Fremont Street
San Francisco, CA 94105

Dear Mr. Takata:

COMMENTS ON THE DRAFT RECORD OF DECISION FOR IRON MOUNTAIN MINE, AUGUST, 1986

The Department of Health Services (DHS) has reviewed both the Environmental Protection Agency's (EPA) Public Comment Feasibility Study Addendum, July 25, 1986 and the Draft Record of Decision (ROD), August, 1986 on Iron Mountain Mine. The former report is an addendum to the EPA Public Comment Feasibility Study Report dated August 2, 1985. DHS agrees with the general approach and strategy of EPA's recommended remedial action for Iron Mountain Mine as outlined in the draft ROD, but we suggest change, clarification or definition on some points.

The strategy calling for a phased implementation of several operable units is in the best interest of the State. We understand these units to be: partial capping of cracked and caved ground areas above the Richmond orebody; surface water diversion of Upper Spring Creek, South Fork Spring Creek and Upper Slickrock Creek; and enlargement of the Spring Creek Debris Dam. The ROD should also include provisions for establishing base line data on surface water measurement and sediment transport, in addition to the monitoring program assessing the impact of each component before the next is implemented. Further, a clearer definition of the areas to be included in the partial capping alternative is necessary.

We support EPA's selection of the combined alternative number nine (CA-9) because of its presumably lower operation and maintenance costs. We further concur that final commitment to injection of low density cellular concrete (LDCC) into the underground mine workings as a source control for acid mine drainage (AMD) be reserved until the results of the pilot and demonstration tests prove its feasibility. The ROD's ground water investigation to evaluate LDCC injection should be broadened to include a hydrogeologic investigation of flow paths in the highly fractured rock zones.

We recommend immediate implementation of operable units located on or upstream of Iron Mountain Mine property which are unaffected by the results of the pilot/demonstration testing of the LDCC. We request, however, a more detailed analysis of the costs to the State for implementation and operation and maintenance of these units. Specifically, we need to know the State's share of these costs for State fiscal years 1986-87 and 1987-88.

EPA should specify in the ROD that additional remedies will be implemented if site clean-up objectives are not met by the proposed plans or if implementation of the plans creates a condition of imminent and/or substantial endangerment.

Finally, the planning and design of the operable units and of the LDCC pilot and demonstration tests must include a DHS input, review and approval process.

AMD at Iron Mountain Mine poses a serious environmental threat, and we look forward to working with EPA towards a solution. Please direct future communication to the attention of:

Anthony J. Landis, P.E., Chief
Site Mitigation Unit
Northern California Section
Department of Health Services
4250 Power Inn Road
Sacramento, CA 95826

If your staff have any questions regarding these comments, please have them contact Candace A. McGahan of our office at (916) 739-3398.

Sincerely,

James T. Allen

James T. Allen, Ph.D.
Chief, Northern California Section

cc: Mr. William Crooks, RWQCB, Sacramento
County of Shasta, DPW, Redding

Attachment 3

STATE OF CALIFORNIA GEORGE DEUKMEJIAN, Governor

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD—
CENTRAL VALLEY REGION
3201 S STREET
SACRAMENTO, CALIFORNIA 95816-7090
PHONE: (916) 445-0270

9 September 1986

Mr. Keith Takata, Chief
Environmental Protection Agency
Superfund Programs Branch (T-4)
Toxic Waste Management Division
215 Fremont Street
San Francisco, CA 94105

FINAL COMMENTS - REMEDIAL INVESTIGATION/FEASIBILITY STUDY FOR IRON MOUNTAIN MINE

This letter contains the Regional Board staff's final comments and recommendations regarding a CERCLA cleanup program at Iron Mountain Mine. These comments and recommendations are based on our review of the December 1984 Remedial Investigation Report, the August 1985 Feasibility Study, and the July 1986 Feasibility Study Addendum.

Our own goals and objectives for an acid mine drainage control program at Iron Mountain Mine are as follows:

1. Improve water quality in the Sacramento River downstream of Keswick Dam so as to protect aquatic life and eliminate potential impacts on domestic water supplies in this portion of the river.

2. Improve water quality in lower Keswick Reservoir and the Spring Creek watershed to restore some measure of beneficial uses in these waters.

3. Implement a mine drainage control program which provides assurance of long-term effectiveness with minimum operating and maintenance needs. (The control program should not be dependent on future water storage and dilution policies, and should consider the inherent instability of the mountain area.)

In reviewing combined alternatives CA-1 through CA-9, we believe that implementation of CA-9 would most effectively achieve the above-stated goals. We concur with the phased approach to implementing CA-9. Capping of the ground surface over the Richmond ore body should be initiated as soon as possible, as should the recommended pilot studies needed to determine the feasibility of using low density cellular concrete (LDCC).

We support a request for funding of the principle water management actions; the upper and South Fork Spring Creek Diversions and enlargement of the Spring Creek Debris Dam. The design studies for these facilities should proceed. However, we recommend that the diversion facilities on South Fork and upper Spring Creek be designed with the capability of releasing water downstream to control pH in lower Spring Creek and Spring Creek Reservoir. The need for pH control in Spring Creek Reservoir will depend ultimately on the success of the source control program. With adequate source control, it may be possible to raise the pH to a level which would cause metal precipitation in Spring Creek Reservoir as opposed to Keswick Reservoir, where metals currently precipitate. In addition, any plan to construct water storage and diversion facilities for the purpose of adequately diluting acid mine drainage would be inadvisable without a long-term agreement with the Bureau of Reclamation concerning operation of these facilities in conjunction with releases from Keswick and Shasta Dams.

We recommend that the upper Slickrock Creek Diversion be included in the initial phase implementation only if initial studies indicate that the waste rock material, which presumably produces the Big Seep discharge, will not be used in the formulation of the low density concrete.

To summarize, we recommend that the Superfund cleanup program at Iron Mountain Mine proceed as follows:

<u>Phase I</u>

- Surface capping of the ground overlying the Richmond ore body.
- Pilot and demonstration studies on the feasibility of LDCC.
- Request funding for water management alternatives and initial design studies.
- Evaluate water quality impacts.

<u>Phase II</u>

- Implement filling of the underground workings with LDCC if Phase I studies indicate effectiveness.

(or)

- Implement alternative source control, such as lime/limestone or other treatment of major point sources.
- Evaluate water quality impacts.

<u>Phase III</u>

- Complete water management alternatives (if needed).
- Evaluate water quality impacts.

In conclusion, we wish to express our appreciation for the efforts of your agency and CH2M Hill in completing the Remedial Investigation/Feasibility Study and helping to resolve this long-standing water quality problem.

William H. Crooks

WILLIAM H. CROOKS
Executive Officer

cc: U.S. Bureau of Reclamation, Sacramento
Department of Fish and Game, Region I, Redding
Department of Health Services, Sacramento
Water Resources Control Board, Division of Water Quality, Sacramento
CH2M Hill, Redding